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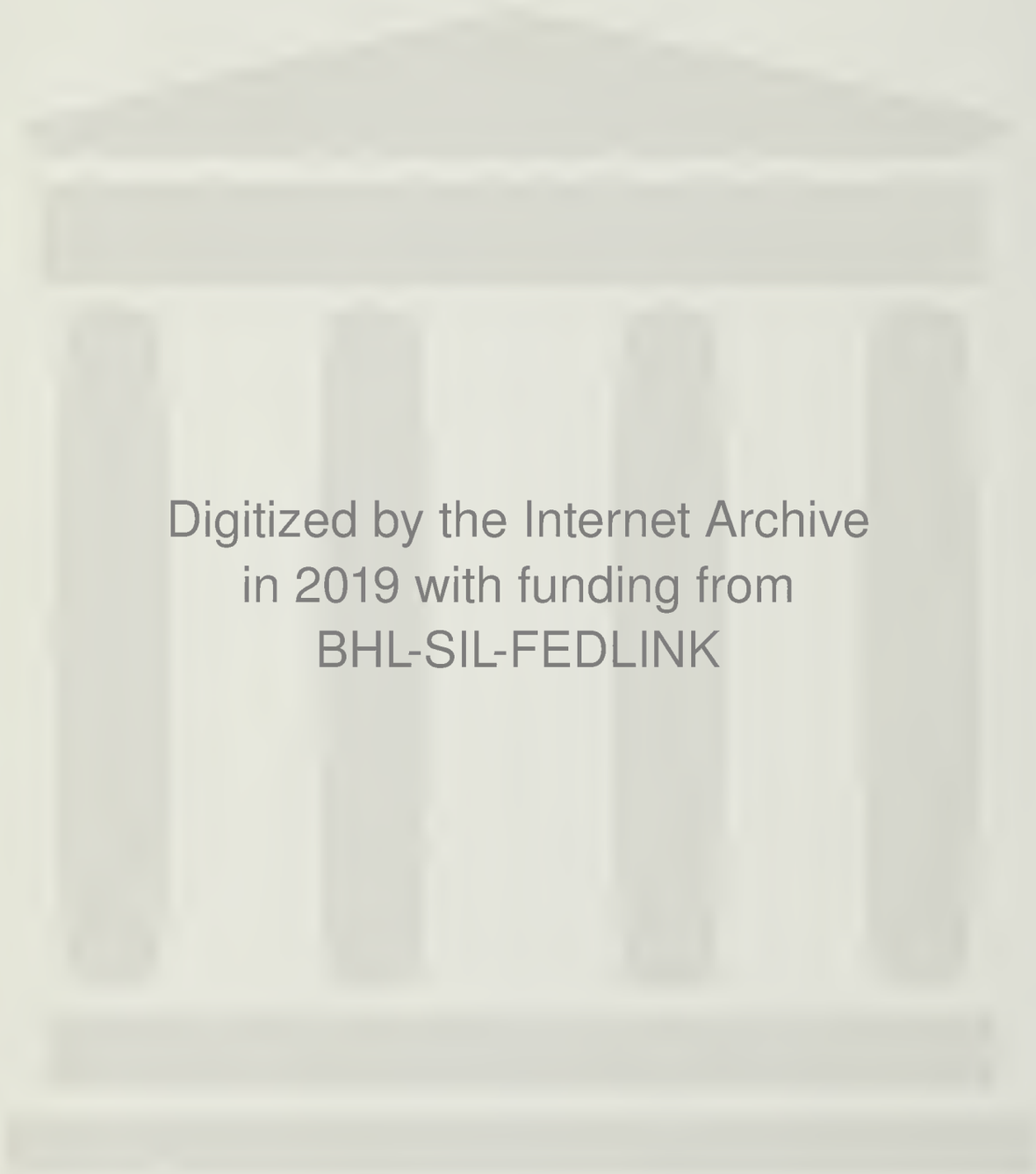
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RARE OLD PUBLICATIONS IN MICHIGAN HERBARIA

Rogers McVaugh
University of Michigan Herbarium, Ann Arbor

The term "herbarium" today usually brings to mind a collection of pressed and dried plant specimens, sometimes the property of an individual but usually belonging to a museum, a college or university, or some other public institution. Herbarium specimens of vascular plants are now usually mounted on sheets of paper of a standard size, and filed individually, but in some desired order, in wooden or metal cases where they may be available for study and research.

The original herbarium, or "Hortus Siccus," however, as it began to develop in Europe in the 16th and 17th Centuries, was a much less pretentious affair. Almost every botanist had his own herbarium, consisting primarily of plants that he himself had collected locally, with the addition of such duplicates as he could obtain from his friends and correspondents. These personal herbaria were smaller than most institutional herbaria today, and many of them differed from modern collections in one important respect: The mounted specimens, glued or otherwise affixed to paper, were assembled into books of a convenient size, often bound in leather or other hard covers and shelved like any other book. Some of these early herbaria, beautifully and sumptuously bound, are today among the botanical treasures of the world's great museums. The practice of binding herbaria into books, however, did not recommend itself to botanists who wanted to study particular groups of plants. The specimens in the bound volumes were not interchangeable, which meant that anyone who wanted to study all the willows (for example) in several different herbaria, first had to locate all the specimens in each individual volume, then assemble the volumes in some way to compare them. The system, in other words, was neither open-ended nor convenient, and the custom of preserving herbaria in books fell into disuse about the beginning of the 19th Century, except as students and amateur botanists began their collections in this way.[1]

Interestingly enough, however, there is a lineal descendant of the bound herbarium-volume which has persisted through the 19th Century and well into our own. This is the so-called *flora exsiccata*, a set of dried plants of one particular region or one particular plant group, distributed as a unit. Such [*plantae*] *exsiccatae*, or dried plants, were

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[1]One of the most interesting such collections now in the Herbarium of the University of Michigan is the seven-volume set comprising the original herbarium of Douglass Houghton, the first State Geologist of Michigan. Most of the specimens are from the vicinity of Troy, New York, collected in 1829 when Houghton was 20 years old and a student of Amos Eaton's at the Rensselaer Institute; some were collected the following year, when Houghton was an assistant professor at the same place, and a few during 1831, when he was surgeon and botanist on the first Schoolcraft expedition to the sources of the Mississippi River.

often collected in many duplicate sets, and sold or exchanged by the collectors. In recent years the *Plantae Exsiccatae Grayanae* were sent out in about 100 equivalent sets of 100 specimens at a time, each specimen accompanied by a printed label bearing information about the bibliographic history of the species, together with full data relative to the place of collection and the habitat, and pertinent information about the plant itself. The more recent sets of *exsiccatae* have customarily been sent to the recipients in the form of individual herbarium specimens, but a number of the earlier ones were distributed as units, and were intended as such; sometimes they were bound by the senders into books, sometimes not; often they were accompanied by printed title page and index, sometimes by a few paragraphs or pages of explanatory text, and (most important to taxonomists today) the printed labels with the specimens sometimes included descriptions of new varieties or species.

The International Code of Botanical Nomenclature now specifies that anyone may describe and name a plant that has previously been unknown to science, providing that he complies with certain regulations in the Code, but providing especially that he distribute to the botanical public a *printed* description of the plant he intends to name as new. Names may not be validated by announcing them at a public meeting, or by sending out handwritten or typed descriptions—only by distribution of printed matter. The reader will see at once where this is leading: Most printed matter today (and in the 19th Century as well), was distributed in the form of books, pamphlets, and periodical literature. As such, the material was customarily given a place on the shelves of some library, and thus remained permanently available for consultation. But why should not one of the bound sets of *exsiccatae* be considered a book? It has a title page, date, author, printed text, and index; it has been widely distributed to the botanical public. It differs from a conventional book only in having dried plant specimens pressed between the pages and forming an integral part of the volume as a whole. Why then does the Code of Nomenclature specifically provide that "on or after 1 Jan. 1953" the publication of new names may not be effected by the distribution of such *exsiccatae*?

The answer is not hard to find. These collections of dried plants are not really equivalent to books, even though they may be bound in book form. At the time of distribution they are hardly ever represented by more than 100 copies, and usually by fewer than this. This means that even at first they do not reach a very wide botanical audience. By the time they are a century old, most of the copies will have been broken up and distributed as individual specimens through herbaria; or some or all of the specimens lost from the pages, or destroyed. Of the three publications discussed below, none is known to be represented now by more than two or three unbroken sets. Finally it may be said that botanists have never consistently classed *exsiccatae* as literary contributions, but rather as collections of specimens accompanied by printed matter. Thus for the most part *exsic-*

catae are not listed in published bibliographies, library catalogues, and the like, and many botanists are hardly aware of their existence. The Code rightly discourages the practice of publishing new names for plants in this way, just as it condemns publication in ephemeral media such as daily newspapers and seed catalogues. On the other hand, it is necessary to take into account the fact that in the past many new names were first put before the public by the distribution of printed matter accompanying just such sets of dried plants. To invalidate all these names now would mean that some well-known and long-accepted plant names would have to be changed, and for this reason the older names published in this way are still considered validly and effectively published. Two such names well known to Michigan botanists are *Panicum xanthophysum* and *Calamagrostis inexpansa*, both published by Asa Gray in the work described below.

Because of the great rarity of most of these sets of dried plants, and because botanical activity in Michigan has been of recent development as compared to that in the great botanical centers of Europe and even in the eastern part of the United States, it is interesting to be able to report here upon the existence in Michigan herbaria of three complete *exsiccatae*, dating respectively from 1805-1814, 1826-1827, and 1834-1835.

1. NORTH AMERICAN GRAMINEAE AND CYPERACEAE, by Asa Gray

Some years ago Rickett and Gilly[2] reported upon this, Asa Gray's second botanical publication. They noted that a "bound copy of Part I is preserved in the library of the New York Botanical Garden . . . and a bound copy is in the herbarium of the Philadelphia Academy of Natural Sciences." They seem to have seen a bound copy of Part II only in the Philadelphia Academy. They noted that some additional specimens, from Part I as well as from Part II, are scattered through the herbarium of the New York Botanical Garden, and that a similar "dispersed set is in the Gray Herbarium." They commented that the eminent agrostologist Trinius "had access to a set of this work and was one of the first to use the names published there" [i.e. about 1841]. With respect to additional sets of Gray's *exsiccatae*, Rickett and Gilly said merely "Other bound or dispersed sets are undoubtedly in existence."

It was therefore a matter of unusual interest that a complete set was found in the herbarium of Wayne State University (WUD[3]), where it forms part of a collection of ten volumes formerly the property of H. P. Sartwell (1792-1867) of Penn Yan, New York. Sartwell was one

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[2]Rickett, H. W., and C. L. Gilly. Asa Gray's earliest botanical publications (1833-1836). Bull. Torrey Bot. Club 69:461-470. 1942.

[3]WUD is the internationally accepted abbreviation for the herbarium of Wayne State University, as listed in Index Herbariorum, 5th edition, p. 56 (1964).

of Gray's correspondents, and indeed collected several sets of specimens that were distributed in 1834 and 1835 among the other Gramineae and Cyperaceae. There is evidence among the other specimens in Sartwell's herbarium that he corresponded with Dennis Cooley, who from 1827 until his death in 1860 lived in Macomb County, Michigan, and there are a few specimens indicating that Sartwell himself collected near Detroit and Windsor; but I have not been able to establish any other connection between Sartwell and the State (or Territory) of Michigan. Dr. C. M. Rogers, through whose kindness I have been able to examine the collections, informs me that there is apparently no record of how this part of Sartwell's herbarium came to Wayne, presumably long after his death.

20. Calamagrostis inexpansa (*sp. nov.*) panicula oblonga laxiuscula, floribus approximatis appressis; glumis subequalibus oblongo-lanceolatis acutissimis, inferiore perianthio ½ longioribus; valvula inferiori superiore ½ majori, seta (recta) supra basin exserta vix æquante; pilis glumas subduplo brevioribus; processu barbato.

HAB. Pen Yan, New-York. Dr. H. P. Sartwell.

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28. Panicum xanthophysum (*sp. nov.*) culmo (simplici aut basi ramoso) panicula foliisque glabris; vaginis villosis, foliis lato-lanceolatis valde nervosis acutissimis, basi ciliatis; panicula simpliciuscula paucifl ra, ramis erectis vel adpressis; spiculis globoso-obovatis pubescentibus; gluma inferiore flosculis sub duplo breviore, superiore eosdem æquante 9-nervi; flore masculo bivalvi hermaphroditum glabrum obovatum sub-æquante.

OBS.—*P. latifolio* affinis.

HAB.—Pine Plains, near Oneida Lake, New-York.

Fig. 1. The labels bearing the original descriptions of *Calamagrostis inexpansa* and *Panicum xanthophysum*. These seem to have been printed in vertical strips with a margin of about one-half inch on each side, then cut apart as indicated by the ink lines drawn at the bottom.

Fig. 2. (facing page). The title page of the Wayne State University copy of the first volume of Gray's *North American Gramineae and Cyperaceae*, bearing Sartwell's stamp.

W.P Cartwell.

NORTH AMERICAN

GRAMINEÆ AND CYPERACEÆ,

BY ASA GRAY, M. D.

PART I.

NEW-YORK:

PRINTED BY J. POST, 101 JOHN STREET.

.....

1834.

The Wayne copy of Gray's *Gramineae and Cyperaceae* consists of two bound volumes, each stamped "H. P. Sartwell" on the title page. The two are quite differently bound, and slightly different in size; the pages in Part I, of a good white paper, measure about 37 × 25.5 cm, whereas those in part II, of a thinner and slightly brownish paper, measure about 35.5 × 26.5 cm. Each volume includes 100 specimens, each on a separate page with its own printed label, the labels numbered consecutively 1-100, and 101-200. Part I includes in addition a title page, dedication page, a one-page introduction and explanation of the work, and a page bearing the index to nos. 1-100. Part 2 includes in addition to the specimens a title page identical with that of Part I (except for the change from I to II and in the date from 1834 to 1835); a one-page index to nos. 101-200; and a printed correction-slip pertaining to the names of three species in Part I.

As the paper on which the introductory pages are printed is different in both parts from the paper on which the plants are mounted, it seems that the printing, and the assembling of the specimens, were carried on separately. Rickett and Gilly note that at least some of the sets seem "to have been issued unbound and probably unmounted." These authors quote Gray as offering to have several copies of Part I bound up himself, probably in the fall of 1834, for distribution to Torrey and others. There is nothing in Sartwell's copy of Part I to show whether or not he received a bound copy from Gray, but it is probable that his copy of Part II was presented to him in this way. On the blank page preceding the title page is an inscription in Gray's hand: "Dr. H. P. Sartwell from the author"; furthermore there is a hand-written note from Gray to Sartwell pasted on the page after the index. Gray had acknowledged in Part I the help he had received from Sartwell in assembling the sets for this *flora exsiccata*, but he still needed additional material of some species. He therefore indicated by pencilled notations near the labels in Part II the species that he wanted. His note read: "Of those marked + I wish more specimens [;] those +! I very much need." He did not hesitate to make his wishes known; of 100 species in Part II, 43 are marked "+" and 9 others are marked "+!".

It is an interesting commentary upon the herbarium practices of the time that although Sartwell evidently kept the specimens as a unit, and thought of them as books (in one note written 22 February 1837 he mentioned "Gray's grassbooks 1 & 2"), he loaned individual specimens to his correspondents by the simple expedient of cutting out pages and sending the mounted specimens, carefully re-inserting and taping the cut pages when they were returned. In this way he sent a number of specimens for study to Professor James Hadley of Fairfield, New York, Gray's former Professor of Chemistry and Materia Medica and the person to whom Gray had dedicated the *Gramineae and Cyperaceae*. Sartwell was also much interested in the genus *Carex*, and in Part II the specimens of this genus bear a number of annota-

tions by specialists to whom he submitted them.

The specimens in the *North American Gramineae and Cyperaceae* were mainly from central New York, where Gray collected between 1828 (when he was not yet 18 years old), and 1835.[4] In the published work 71 species (29 in Part I, 42 in Part II) are labelled as from the "Western part of New-York," but presumably most of these came from between Utica and Oneida Lake, in what would now be considered the central part of the state. Gray's correspondents Crawe and Sartwell sent him specimens from a little farther west and northwest, but still not really from western New York.

About two-thirds of the species in Part I are from New Jersey, where Gray collected in the pine-barrens and near the Atlantic coast in 1833. One grass in this same Part, *Koehleria cristata*, was collected for Gray in "Michigan territory" by a friend, Dr. N. W. Folwell, who lived in New York.[4]

In Part II about four-fifths of the species are labelled as from western New York or simply from Utica, from near Oneida Lake, or from Oneida County. Presumably these represented Gray's own collections. Many of the others were credited to Sartwell, or to Dr. J. B. Crawe of Watertown, New York, Gray's acquaintance and one-time field companion.

The new names and new combinations published in Parts I and II are listed by Richett & Gilly; actually they are not very numerous. Of interest to Michigan botanists are the following, including those of the two species of grasses mentioned above, both described for the first time in the *North American Gramineae and Cyperaceae*, Part I, early 1834:

Calamagrostis inexpansa A. Gray, Gram. & Cyp. 20. 1834.
Panicum xanthophysum A. Gray, Gram. & Cyp. 28. 1834.

The new combination *Muhlenbergia sylvatica* (Torr.) Torr. in A. Gray was validly published in the same work (p. 13), as was also the new name *Vilfa vaginiflora* Torr. in A. Gray (p. 3) [*Sporobolus vaginiflorus* (Torr. in A. Gray) Wood].

2. SAULES DE LA SUISSE, by N.-C. Seringe

Nicolas-Charles Seringe (1776-1858), of French birth, lived in Switzerland for many years, and is known chiefly for his collaboration with A. P. DeCandolle in the preparation of treatments of certain plant families for the *Prodromus Systematis Naturalis Regni Vegetabilis* (1824-1830). In 1815 he published at Berne an account of the willows

[4] For an account of Asa Gray's early years in central New York, his training in medicine, and the beginnings of his interest in botany, see the first chapter (pp. 1-18) of *Asa Gray*, by A. Hunter Dupree (Harvard University Press, Cambridge, 1959). N. Wright Folwell, Gray's classmate in medicine, is mentioned on p. 19.

of Switzerland,[5] a book of a hundred pages, and his own first publication of any size. It is not generally known that 10 years before this he had begun publication of an account of Swiss willows in another form. This earlier publication, of which presumably only a very small number of copies was issued, bears the title "Saules de la Suisse." It is excessively rare today even in Switzerland; John Briquet, the biographer of Swiss botanists, seems to have known of the first three fascicles only.[6]

In 1952 the University of Michigan bought from a European bookseller a set of "Saules de la Suisse" that seems to be complete in 7 separately bound fascicles ("Cahiers"). Each fascicle measures about 24 × 33 cm, and is saddle-stitched, with a tough flexible heavy paper cover bearing a printed enumeration of the species and varieties that are included. The whole work treats 88 consecutively numbered taxa (most of which today would be called "forms"). At least two (nos. 39 and 40) are specimens of fungi that parasitize leaves.

One of the earlier biographers of Seringe referred to the "Saules de la Suisse" as "a curious work, in which dried specimens take the place of pictures," and this states the case fairly enough. Each fascicle includes, for every species or variety treated, one or more small but carefully selected and prepared specimens of the plant itself. Often different growth stages are represented by specimens collected at different times; often flowering and fruiting specimens are both included; sometimes vegetative shoots with stipules, bark specimens, or even the characteristic galls formed on certain species are shown.

In Cahiers 1-5 each specimen is mounted on a page together with a small printed label bearing the name of the taxon and the number assigned to it by Seringe, e.g. "5. Salix aurita. Smith." Other information about the specimens, including some bibliographic references, some descriptive matter, details of habitat, uses, etc., of the plant, and place and date of collection, is gathered together on an introductory page of printed text. The introductory pages are headed "1er CAHIER," "2^{me} CAHIER," etc., and each is dated at bottom.

Summary of Cahiers 1 - 5

Cahier	Date	Included taxa
1	Dec 1805	1-6
2	Dec 1805	7-11
3	Dec 1805	12-18
4	Dec 1806	19-27
5	Jan 1808	28-44

In the fifth Cahier, for the first time, Seringe proposed a new species, *Salix kanderiana*. It is his no. 42, described briefly and con-

[5]Essai d'une Monographie des Saules de la Suisse. 100 pp., 8vo., 2 plates. Berne, 1815.

[6]Briquet, John. Bull. Soc. Bot. Suisse 50A: 437. 1940.

trasted with *Salix acuminata*. Like the others mentioned below, this name seems to have been validly published here, several years before it appeared in the "Essai" of 1815.

In the 6th and 7th Cahiers, the style is changed a little. The dates (1809 and 1814, respectively) are printed on what corresponds to a table of contents pasted to the front cover. There is no separate introductory page in addition to the list on the front cover, but the labels that accompany the specimens are more or less expanded to include the kind of information that made up the preliminary text in fascicles 1-5. Thus the label for no. 47, *Salix serpillifolia* Willd., lists French and German vernacular names, and localities at which the plant occurs, and includes an 8-line description contrasting this species with another. Two new species (*Salix grandifolia*, no. 55, and *S. uliginosa*, no. 60), are named and described in Cahier 6.

The work ends with nos. 45-60 in Cahier 6, and 61-88 in Cahier no. 7. With the issue of this last fascicle Seringe seems to have concluded the work; evidently he was already planning his "Essai" which was to be published in 1815, for the last line on the "contents" page of no. 7 reads: "Des remarques sur les 7 cahiers de cette collection vont être publiées."

3. HORTUS SICCUS LONDINENSIS, by Mariano Lagasca

Mariano Lagasca (1776-1839) was one of the ablest botanists of his time. Colmeiro said that he was "the leading botanist of our century, and for many years the only one who upheld in the scientific world the honor of Spanish botany." Unfortunately he was one of the victims of the Spanish counter-revolution of 1823, in which he lost most of his possessions including his manuscripts, his books, and his herbarium. He left Spain and emigrated to England, where he lived for a number of years under difficult circumstances. Perhaps in an effort to supplement his income, he planned to issue a *hortus siccus* including the common flowering plants and ferns growing within a radius of 20 miles around London. Assisted by his two eldest sons, he hoped to prepare a number of parts each containing 25 plants, and sell 30 sets of each part. The price was fixed at one pound per part. As originally announced, it was intended to publish one part every other month, or six each year, but this was too ambitious an undertaking. The first set of 25 plants, with the accompanying text, seems to have been delivered in December, 1826; the second, third, and fourth sets are all dated 1827. From a note at the beginning of part 3, that fascicle appears to have been published about the first of April; part 4 was promised for the first of July. The first "volume" was completed with part 4, and no more was ever issued. (Lagasca stated in the preface to the first part, that "the work may be bound in volumes of four parts without any injury to the specimens.")

Apparently no complete copy of the *Hortus Siccus Londinensis* has

survived in England. Three of the four fascicles came many years ago into the possession of the British botanist G. Claridge Druce, who published a note with an enumeration of all the specimens.[7] The specimens themselves, with the rest of Druce's large herbarium, were ultimately bequeathed to Oxford University. Druce stated that as far as he could determine there was no copy of Lagasca's work in the British Museum (Natural History). In recent years I have inquired about it, but I have never found any indication that there may be another copy at any of the great English herbaria.

Perhaps not surprisingly, however, there proved to be three complete sets in Mexico City. Lagasca, of course, had many ties with Vicente Cervantes and the other Spanish botanists in Mexico, as well as friends and acquaintances among political and religious figures of the day. The late Professor Faustino Miranda very kindly arranged an exchange by which one copy came from Mexico to the University of Michigan.

Each of the four fascicles of Lagasca's work begins with a title page, and on the following page a pasted-in "Contenta" slip bearing a neatly printed list of the species included in that particular part. The full title, not a particularly long one for the time, is as follows:

Hortus Siccus Londinensis; or, *a Collection of dried specimens of Plants, growing wild within twenty Miles round London, named on the Authority of the Banksian Herbarium, and other original Collections.*

The first fascicle includes an additional, prefatory page, following the title page, announcing and describing the intended publication. Lagasca stated that the "chief aim of its Publication is to assist beginners, and to gratify those lovers of the Science, who, from their other pursuits, cannot devote themselves to the laborious employment of collecting, drying and arranging in a Herbarium, the Plants of their native country."

Although the original intention was to issue the sets in parts of 25 species each, a note in the third fascicle announced that the size was being increased to 30 species per part. Thus the first three parts include a total of 80 species. Part 4 contains 40 species (81-110, and a "Supplementum," nos. 111-120). No new species are described in the work; as Lagasca said in the preface, "In a Country like England, abounding in all that is necessary for instruction," the work might have been superfluous "were its object the advancement of Botanical Science." Most of the species are the ones that were common around London, and so well known to botanists. Druce, however, pointed out that several of the plants represented the first known records for the county of Middlesex, even though none was very rare.

Each specimen in the work is accompanied by its own printed label. An interesting feature of these labels is the fact that Lagasca

[7] LaGasca and his 'Hortus Siccus Londinensis'. Jour. Bot. Brit. For. 46: 163-169. 1908 (with appended biographical and bibliographical notes, pp. 169-170, by James Britten).

included on them not only the name of the plant, and information about its distribution in the London area, but also what he understood to be its distribution in Spain. His own primary research interest was in the Spanish flora, and apparently even here in London it was occupying a part of his time and thought.

None of the three works described above can be said to have influenced the Science of Botany to any great extent; few taxonomists today have ever heard of any of them. Nevertheless each has its own peculiar interest. Gray's *Gramineae and Cyperaceae* and Seringe's *Saules* are of some importance nomenclaturally because of the few new names that were published in them. All three are of historical interest because they are illustrative of a method of publication that was superficially attractive, but was eventually abandoned because of its inefficiencies. All of them are of very real importance, moreover, because they provide factual information about plant distribution in certain limited geographical areas, at a period when rapid changes in all habitats were beginning to come about because of man's activity.

Publications of Interest

HANDBOOK ON ORCHIDS. Brooklyn Botanic Garden, Brooklyn, N.Y. 11225, 1967. 81 pp. $1.25. Enough of our readers are interested in orchids to justify calling attention to this handbook, actually the latest issue (Vol. 23, No. 2) of the Brooklyn Botanic Garden's quarterly *Plants & Gardens*. Among the two dozen articles and features on orchids is one, "Growing Native Orchids," by our own Michigan orchid man, Fred Case.

THE MUSHROOM HANDBOOK. By Louis C. C. Krieger, with a new preface and appendix on nomenclatural changes by Robert L. Shaffer. Dover Publications, New York, 1967. vii + 560 pp. + 32 col. pl. $3.50. A facsimile (but slightly enlarged) reproduction of the 1936 Macmillan edition of a handbook first published in 1935 by the New York State Museum, with the scientific names brought up to date in an appendix but no changes in the original thorough introduction, keys, descriptions, or bibliography. Although originally intended as a popular guide to the higher fungi of New York state, it is a useful work in Michigan as well. Although the publishers are to be congratulated on an excellent printing job, their own blurb on the back cover fails to cite the correct number of pages or of figures (there is no fig. 13, it having originally been a forest type map of New York) and is guilty of considerable exaggeration in referring to Krieger as "America's foremost mycologist."

NOTES ON THE GENUS *SUILLUS* (BOLETACEAE)

Alexander H. Smith and Harry D. Thiers
University Herbarium and Department of Botany,
The University of Michigan, Ann Arbor, and
Department of Biology, San Francisco State College,
San Francisco, California

Since first publishing on *Suillus* (Smith & Thiers, 1964) we have continued to gather data toward an eventual monograph of the group for North America. As we are well aware, there is still much work to be done before we can claim to have a reasonable understanding of the taxa in this group for this continent. With vast areas of "*Suillus* country" still very inadequately sampled we do not as yet have sufficient knowledge of the extent of gene exchange or the mechanism by which it occurs. All that can be said at present is that obviously gene exchange is going on at a rapid rate. One is tempted to assume it occurs through hybridization but this has not been established experimentally. That previously undescribed taxa can still be found in a state such as Michigan, in which so much collecting has been done, only re-emphasizes the need for more intensive as well as extensive field work.

During the past season three species were collected which deserve special mention. One was a heavy fruiting of a generally rare species, *S. albidipes*; the second, the discovery in Michigan of the fungus we believe Frost discovered in New England and which was published in Peck (1889) as *Boletus unicolor;* and the third appears to be a European species which has long but improperly been regarded as a synonym of *Suillus granulatus*.

1. *Suillus albidipes* (Peck) Singer.

During the fall of 1967 an unusual fruiting of this species occurred in a pine plantation near Hell, Michigan, in Livingston County. Dr. Bruce Fralick, the owner, planted there a variety of pines and other conifers. The fruiting was first discovered by Florence Hoseney and Ruth Zehner in the course of general collecting in and near the Pinckney Recreation Area. On Oct. 28 Smith made a special effort to estimate the number of basidiocarps present by pacing off and counting the number on five transects through the particular area involved in the fruiting, which was roughly ten acres of white pine mixed with other conifer species. The rough calculation indicated that on that morning about 5,000 basidiocarps of *Suillus albidipes* in various stages of development were present in the area. To our knowledge this is the largest fruiting of this species on record. It has also furnished reliable data on variation in the species, as well as data on the fruiting pattern.

Most of the fruiting occurred in circles marked by the outermost

branches of each tree (the trees are not yet pole size); anywhere from 10-15 basidiocarps occurred under almost every tree whether it was white pine or some other species. In other words, proximity to the tree was more likely the result of ecological factors than a genetic affinity of the fungus for the species of tree. Where there were open spaces caused by cutting Christmas trees, the basidiocarps were more scattered singly or in clusters. In these open areas many of the older basidiocarps were whitish from fading but the characteristic pale vinaceous-cinnamon to cinnamon-ochraceous colors were present on young caps beside the old ones. The false veil was regularly well developed, varied from white to vinaceous buff, and in age all signs of it were often obliterated. Usually, however, the marginal area of the pileus retained a patchy appearance from the veil remnants. Colored glandular dots were readily visible over the apical region of the stipes at maturity. Pileus size ranged from 4 to 18 cm, a range that dispels any illusion that might have existed in some quarters that *S. albidipes* is a "small" species. However, the most remarkable feature of this fruiting was the extreme constancy of the characters which distinguish the species—color of pileus, nature and color of veil, white stipe at first, and small spores.

Suillus granulatus was fruiting in less abundance at the same time, with young material ample, and no false veil was seen on any of the basidiocarps at any stage of development. *Suillus luteus* was also abundant in the same area but no estimate was made of the number of basidiocarps seen; they were almost as numerous as those of *S. albidipes*. *Suillus brevipes* was conspicuous by its absence. As one might imagine, however, the ground in the part of the plantation studied was practically paved with basidiocarps of the various species of *Suillus* present.

We have no data on the precipitation pattern which preceded this heavy fruiting. Local showers in September, however, must have been the influencing factor for in the Stinchfield Woods of the University's School of Natural Resources, there was practically no fruiting of fungi at the time of greatest abundance at the Fralick plantation. However, two weeks later after heavy rains, the usual fungi including the *Suillus* species discussed above, were there in abundance. The two areas are less than ten air miles apart. The moral for mushroom hunters is obvious: If you do not find your quarry in one woods, try another.

2. *Suillus unicolor* (Frost in Peck) Kuntz. Fig. 1.

Pileus 4-7 cm broad, plano-convex, expanding to nearly plane, thinly slimy-viscid, perfectly glabrous or rarely with a few reddish dots near the margin, color "empire yellow" to lemon-color and constant for the life of the basidiocarp. Context mild, odor not distinctive, when cut pale to bright lemon-yellow, with KOH giving a flush of red and finally bluish-fuscous (the color change on the pileus surface similar).

Tubes decurrent, shallow (2-3 mm in young specimens, 5-6 mm in mature ones), gelatinous, bright yellow, readily separable from pileus; pores minute, bright yellow, not staining when bruised.

Stipe 4-6 cm long, 8-10 mm thick, solid, narrowed downward to a subradicating base, within lemon-yellow in the apex and olivaceous in the base, surface lemon-yellow but staining dull olivaceous where handled, near apex with raised areas of glandules but the dots conclorous with remainder of the surface or in age finally brownish; copious basal mycelium pale yellow.

Spores 7-9 × 2.6-3 μ, smooth, in profile narrowly inequilateral, in face view elongate-subfusoid to nearly oblong, pale yellowish in KOH, pale tawny in Melzer's solution. Basidia 4-spored. Pleurocystidia in fascicles, when revived in KOH with vinaceous brown content and vinaceous brown encrusting debris around the cluster, individual cystidia cylindric to narrowly clavate, 34-47 × 5-9 μ. Pileus cutis of appressed hyaline narrow tubular gelatinous hyphae lacking clamp connections.

Scattered under an aspen-birch-spruce stand near edge of swampy area, northwest corner of Montmorency County, Michigan, July 26, 1967, Smith 74648.

In the dried state the glandular dots are very conspicuous on the stipe. The yellow of the pileus is preserved in drying. Frost did not mention the stipe as staining olive for his *Boletus unicolor.* We are assuming that this character was overlooked. There was no veil along the pileus margin and were no fibrils on the pileus, so it is not likely that this species represents a variant of *S. hirtellus. S. subaureus* is closest but the stipe in it has a ferruginous to fulvous zone in the base when cut, and the color changes on the surface are to brownish. Also the basal mycelium is white, and the pileus has appressed tomentum over the surface to some extent at least.

3. *Suillus lactifluus* (Wither. ex S. F. Gray) comb. nov.
Leccinum lactifluum S. F. Gray, Nat. Arr. Brit. Pls. 1: 647. 1821.

Pileus 4-10 cm broad, obtuse to convex, expanding to plane, surface slimy, color pinkish buff to more or less pinkish cinnamon, in age darker reddish cinnamon, glabrous, in age streaked to some extent beneath the slime or finally distinctly virgate; margin sterile and overhanging the edge as a thin membrane 0.5-1.5 mm wide (as in species of section *Leccinum* of *Leccinum*). Context watery pallid but with lemon-yellow areas especially near the tubes, dull lilac-blue with KOH, red in NH_4OH, olive with $FeSO_4$; odor slight, taste acid.

Tubes pale yellow ("Baryta yellow"), when young and just forming duller, soon beaded with numerous droplets of a milklike latex, these evaporating by maturity, adnate to short decurrent or in intermediate stages slightly depressed, up to 8 mm deep. Pores minute, 2-3 per mm at first but becoming 1-2 per mm at maturity, staining brownish where bruised (cinnamon buff).

Stipe 2-5 cm long, evenly enlarged downward or in age narrowed downward, virgate within with lemon-yellow streaks, staining cinnamon to vinaceous cinnamon in the base; surface pale lemon-yellow overall at first, very inconspicuously punctate above but the ornamentation concolorous with remainder of the surface and not darkening by maturity in spite of the fact that the surface stains brown from handling, colored dots show slightly on the dried specimens.

Spore deposit cinnamon when air dried. Spores 7-9 × 3 μ, in profile suboblong to slightly inequilateral, in face view oblong or nearly so, yellowish in KOH, in Melzer's solution dingy yellowish.

Basidia 4-spored. Pleurocystidia in clusters with vinaceous brown encrusting material when revived in KOH and also many cystidia with colored content, hyaline when fresh but turning vinaceous with KOH; individual cystidia cylindric to narrowly clavate, 34-45 (50) × 6-9 μ. Caulocystida in massive clusters, 50-90 × 7-12 μ, when revived in KOH smooth and hyaline for the most part,

Fig. 1. Suillus unicolor (Smith 74648), ×1.

but with the content finely colloidal and in KOH red only in the content in the tip of the cell, smooth, pedicel flexuous, some surface hyphae with reddish content in KOH also, and with reddish debris between the cells; the red pigment in some clusters of cystidia slowly fading on standing in KOH. Epicutis of pileus of gelatinous hyphae 2-5μ diam., hyaline to yellowish in KOH. Clamp connections absent.

Under white pine, University of Michigan Botanical Gardens, Washtenaw County, Oct. 10, 1967, Florence Hoseney and Ruth Zehner collectors (Smith 75165).

Singer (1967) Taf. VIII, fig. 10, under *S. granulatus*, illustrates the above species admirably except for the slightly colored stipe ornamentation. He illustrates droplets of latex. We have seen this on *S. granulatus* in North America, but never so copiously. The species we have described here is not *S. granulatus* in the usual sense—a species with a spotted stipe. *S. lactifluus* has a thin sterile membranous margin with no other signs of any development that might be construed as a veil. The lack of glandular dots on the stipe when fresh was constant in several baskets full of basidiocarps. The pileus was slimy as in *S. brevipes*. The latter, however, has a smoother stipe which remains white a much longer time.

The situation in regard to this species is most peculiar historically. It happens, however, that the early descriptions of *Boletus lactifluus* describe our material about as perfectly as can reasonably be expected—including the sterile marginal membrane of the pileus. The stipe is not spotted in young to mature specimens. However, Pilat, under the name *Ixocomus granulatus*, gives an excellent illustration—including the brown stains on the stipe. Singer (1947) stated "*Leccinum lactifluum* (With. ex Fr.) S. F. Gray is *Suillus granulatus* (L. ex Fr.) Kuntze ssp. *typicus*."

We cannot accept Singer's statement. As Pilát (1954) has clearly shown (pl. 23) the stipe is not glandular dotted (Fries underlined punctato-granuloso in his description). Hence it is simply not justifiable mycologically or nomenclaturally to accept *S. lactifluus* as the type subspecies of *S. granulatus*. Our observations on the abundant collections made at the University Botanical Gardens verify the existence of a constant taxon in the characters the early workers described. Since it is distinct at the same level as other commonly recognized *Suillus* species such as *S. brevipes*, we recognize it here as an autonomous species related to the latter.

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OBSERVATIONS ON THE BOLBITIACEAE. IV. A NEW GENUS OF GASTROMYCETOID FUNGI

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Whilst curating dried material of the Bolbitiaceae and so called gastromycetoid fungi connected with this agaric family housed at the University of Michigan Herbarium, Ann Arbor, during 1965, several collections of an undescribed member of the group were examined; these specimens possessed characters uniting the genera *Bolbitius*, *Conocybe*, and *Galeropsis* (in its widest sense). Later that same year whilst attending a showing of colour transparencies taken by members of the North American Mycological Association, H. E. Schweitzer showed what I took to be this same fungus; from information later given to me by the photographer, it agreed in all respects macroscopically with the taxon described below. Dr. Clark Rogerson of the New York Botanical Garden, learning of my proposed monographic treatment of the bolbitiaceous fungi, sent for my attention two 'off beat' bolbitii. One turned out to be a member of the *Conocybe lactea-crispa* complex, but the second collection turned out to be the fungus under consideration; however, this time habitat notes and colour transparency accompanied the dried material. This last collection suggested that all the notes available to me should be drawn together and this then confirmed the autonomy of the taxon.

The recognition of this taxon and its placing in a new genus pose several problems, but these must be deferred to a much more lengthy discussion of the *Galeropsis* complex; the purpose of this communication is to place on record this unique fungus in order that its true affinities and distribution may be ascertained. From the herbarium collections which have been made available—and there is little doubt that other collections exist elsewhere hiding under unnamed collections of species of *Bolbitius* or under no name at all—the taxon appears to be fairly widespread in North America west of the Appalachians and east of the Rockies. However, the speed with which the carpophore turns into a gelatinous mass makes the collecting of this fungus difficult. The collections which are to hand have only been found due to patient and slow collecting often in areas under continual surveyance or at the other extreme to very chance collecting.

It is proposed to describe this fungus in a new genus, *Gastrocybe*, because of the gastromycetoid nature of the basidia, the almost symmetrically placed basidiospores, and the reduction of the pileus to a gelatinous mass within a short time after full elongation of the stipe.

GASTROCYBE Watling, gen. nov.

Pileus primo glandiformis vel ellipticus, vel cylindrico-ovoideus vix vel numquam expansus, unctus vel viscidus denique gelatinosus et informis. Stipes aequalis vel subaequalis, vulgo bulbillosus, albido-

hyalinus dein pallidus, fragilis, gracilis, saepe elongatus. Lamellae adnatae vulgo ventricosae ad faciem venosae vel intervenosae, ferrugineae. Caro tenuis, albida vel pallida. Cellulae cuticulae pilei pyriformes vel spheropedunculatae. Basidia et sterigmata aliquantam crassitunicatae. Basidiosporae fere symmetrica, Cheilocystidia copiosa; pleurocystidia nulla.

Pileus ellipsoid-campanulate or conic, hardly or never expanding, greasy to viscid rapidly becoming reduced to a gelatinuous mass, pigmented. Stipe white or hyaline, hollow, fragile and slender often very long. Gills strongly forked, branched and interveined, fused to form a fairly regular honey-comb pattern within the cavity formed between the pileus context and the stipe surfaces. Pileus 'cuticle' hymeniform. Basidia strongly thickened and spores borne almost symmetrically upon prominent thickened sterigmata, cheilocystidia present, specialised; pleurocystidia absent.

Type species: *G. lateritia*, by original designation.

Derived from the Greek *gaster*, *gastros*, belly, referring to the cavity in which the basidiospores are produced, plus *cybe*, head, referring to the pileus.

Gastrocybe lateritia Watling, sp. nov.

Pileus 5-25 (30) mm altus / 2-10 (15) mm latus, ellipticus vel cylindrico-ovoideus, vix vel numquam expansus, viscidus, membranaceus, striatus, fragilis, denique gelatinosus et informis. Stipes 50-100 (130) / 1-1.5 (3) mm, albidus, subaequalis, vulgo sub-bulbillosus, flexuosus vel erectus, laevis vel ad basim albopruinosus. Lamellae ferrugineae, ad faciem venosae vel intervenosae, ramosae vel bifurcatae. Caro tenuis albida vel pallida. Basidiosporae late ellipsoideae, poro germinativo (9.5) 10.5-12 (14) × (6) 7-8 μ, laeves. Cheilocystidia diversiformia, plerumque lecythiformia vel capitata.

Pileus 5-25 (30) mm high × 2-10 (15) mm broad, ellipsoid-campanulate to conic, long, subacute, not expanding or hardly significantly so, greasy, tacky or viscid, membranous, pellucid-striate to disc, especially in immature specimens, then rapidly reduced to a gelatinous mass which adheres to the apex of the stipe, either retaining former shape or becoming amorphous, uniform or slightly darker at disc, light chocolate brown, darkening at maturity and in dried material more dark chestnut, even bay, polished. Stipe 50-100 (130) mm × 1-1.5 (3) mm, pure white, shining, hardly discolouring, equal, flexuous or straight, slightly attenuated upwards, dry, smooth or sparsely pruinose (more so towards base) obscurely striate, fragile, easily collapsing, hollow. Gills rich rust-brown, well-formed with acute margin, branched, forked and interveined, the branches fusing with adjacent gill plates, thus forming a fairly regular honeycomb structure with smaller 'locules' nearer the margin of the pileus. Flesh white in stipe, hardly discernible in pileus; smell and taste not noted. Basidiospores broadly ellipsoid, (9.5) 10.5-12 (14) × (6) 7-8 μ, smooth with a very prominent

germ-pore and broad apiculus, rich honey brown under the microscope. Basidia 4-spored, commencing thick-walled or becoming thickened at maturity, ca. 26 μ long and up to 13.5 μ broad, tapered abruptly at base; sterigmata prominent and wide with mamillate apex when forming. Cheilocystidia capitate, irregularly lecythiform with $\pm$ long (up to 6 μ long $\times$ 1.75 μ), $\pm$ flexuous neck, head up to 4 μ in diameter, body 7.5 μ broad; pleurocystidia absent, those cystidia developing at junction of interveins being cheilocystidia. Caulocystidia absent or present at stipe apex; pilocystidia flexuous, filamentous, irregularly distributed on the stipe, more frequent at base. Pileocystidia absent and pileus 'cuticle' consisting of palisade of irregularly pyriform, hyaline cells up to 18 μ broad and covered on the outer surface with a mucilaginous deposit.

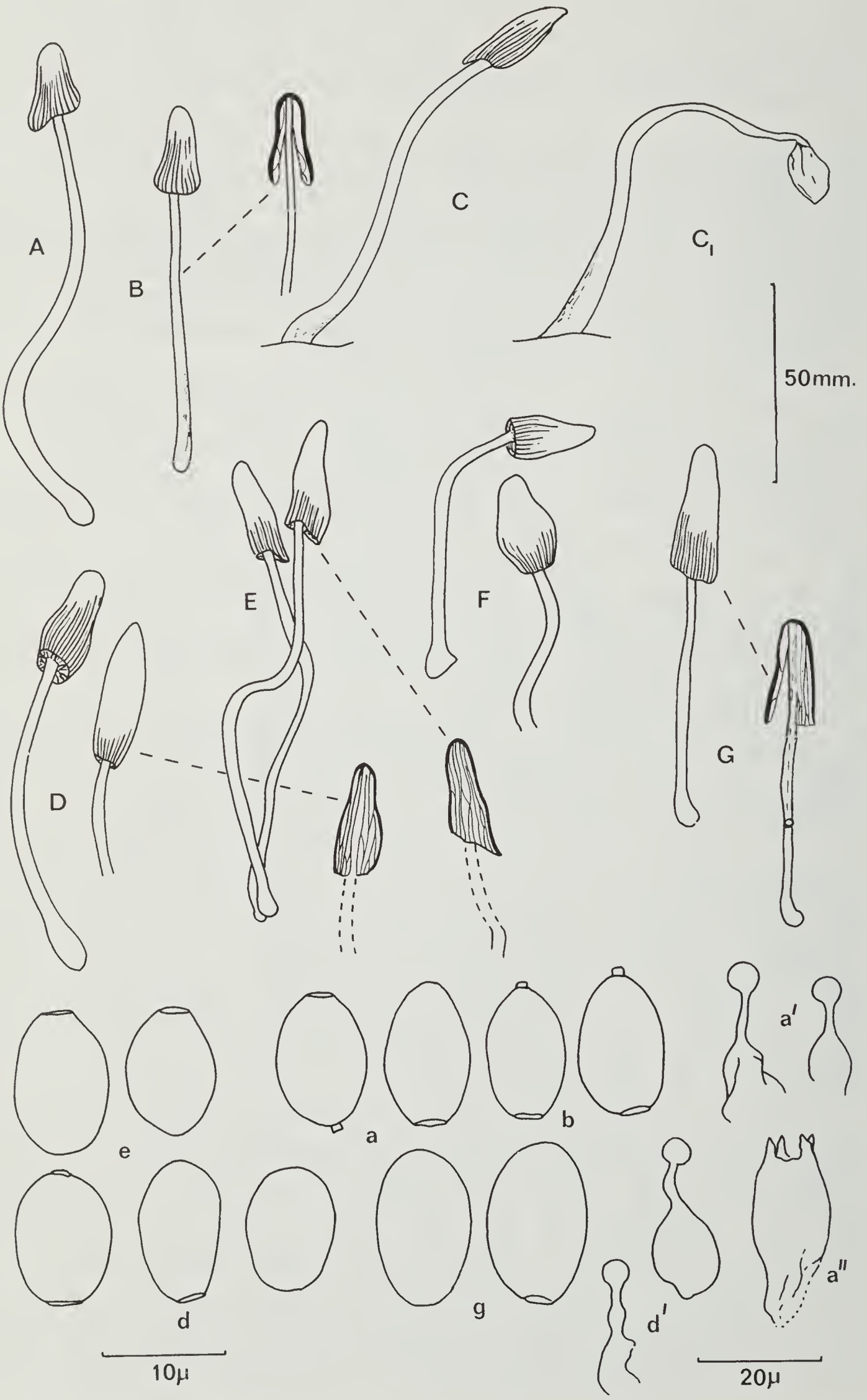
In grass lawns, gregarious or solitary.

The genus differs from *Galeropsis* as typified by *G. desertorum* Vel. in the hymeniform epicutis, the colour of the basidiospores, the 'deliquescence' of the pileus, and the very fragile stature.

Material examined: Old Botanical Gardens, Ann Arbor, Washtenaw Co., Mich. 29 VIII 1947, Mains (MICH); Laramie, Albany Co., Wyoming, 12 VII 1950, R. Solheim (MICH); cemetery, Ithaca, Gratiot Co., Michigan, 29 VIII 1957, V. Potter (MICH); Ithaca, Gratiot Co., Michigan, 31 VIII 1957, V. Potter (MICH, type); Peoria, Peoria Co., Illinois, H. E. Schweitzer; Ogden, Weber Co., Utah, 27 VII 1965, C. Rogerson (NY); also probably (photograph only) a collection by Kauffman, Ann Arbor, Washtenaw Co., Michigan, date ? .

It would be premature to discuss the affinities of this fungus but it is significant to draw parallels with other members of the Bolbitiaceae. First of all, it appears that although the fungus is agaricoid in general aspect it does not seem to actively discharge its spores; it must be considered therefore a gastromycete in the traditional sense (cf. *Weraoa nivalis* Smith, 1965, p. 395). This is based not on actual field observations but on the anatomy of the basidium and the position of the undischarged basidiospores on the basidium. Potter was unable to procure a spore-print and there is no evidence of a deposit on the paper to which the Michigan, Utah, and Wyoming specimens have adhered on drying. The thick wall to the basidium apex and elsewhere in some examples, the thickened sterigmata, and the almost symmetric positioning of the basidiospores lead only to one conclusion.

It has been impossible to obtain complete sections of the pileus cuticle and context because they soon disorganise as described above, to leave only a few pyriform or elliptic cells distributed in mucilage. This therefore resembles in all respects that found in *Bolbitius vitellinus* where it may become one and a half or even twice as thick as the hymeniform epicutis. There is every reason to suppose that it is chemically similar to this layer in *B. vitellinus* and a similar one found in *Suillus* spp., although it was impossible to test the dried material with either Alcian blue or Periodic acid Schiff's reagents. This phenomenon is widespread in members of the Bolbitiaceae although it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is never as well-developed as it is in species of *Bolbitius*; in fact, it is because this character is correlated with other details that it is used to separate *Bolbitius* and *Conocybe*. Even in *Conocybe coprophila* where the pileus is distinctly viscid the thickness of the pellicle is never greater than the thickness of the hymeniderm and never becomes reduced to a gelatinous mass; in *C. tenera* the mucilage layer is quite thin and soon destroyed giving to the fresh specimens of this taxon a greasy-shiny character. It is characteristic of members of the *C. lactea* group (Sect. *Candidae*) for the pileus to become tacky and soft when mature and this same group parallels the taxon under consideration in that the pileus is often long and slender, cylindrical and only slightly expanding; the stipe is also white or hyaline and less distinctly ornamented than in the *Conocybe tenera* group (i.e., *Conocybe*, sect. *Conocybe*) or in the *C. silignea* group (Sect. *Pilosellae*) (see Watling, 1965). It appears the mucilage is a mucopeptide or mucopolysaccharide.

We have no knowledge as yet as to how the spores are dispersed; it does not seem to be a mechanism dependent on scavenging insects as in the Phallales, for none of the collectors mentioned an odour and there is little doubt that of all the three persons involved Potter would have noticed an odour had there been one—not only had he a good sense of smell but most important the specimens were growing gregariously over several feet of lawn.

H. E. Schweitzer (personal communication) informs me that the fungus first appears in the early morning, frequently before the sun rises, a common feature of many species of *Coprinus* and probably the reason why records of many are lacking in local floras, etc. The pileus of *G. lateritia* is reduced to a mucilaginous mass within one hour of the stipe reaching its greatest length. As soon as the sun becomes fairly high in the sky the whole carpophore collapses amongst the grass and rapidly shrivels. Dr. C. Rogerson reported to me that his specimens appeared after a lawn consisting mainly of Kentucky bluegrass (*Poa pratensis*) had been irrigated in mid-summer. The notes accompanying Potter's material also support Schweitzer's and Rogerson's observations.

I am grateful to Prof. A. H. Smith for allowing me to study the specimens housed at the University of Michigan Herbarium, Ann Arbor, and for arranging for me to study under a grant from the National Science Foundation.

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Fig. 1. *Gastrocybe lateritia* Watling. A, a, a', and a": Potter 3654, 31 VIII 1957, Michigan (type); B & b: Potter, 29 VIII 1957, Michigan; C: Schweitzer, VII 1965, Illinois, C_1, same specimen one hour later; D, d, & d': Rogerson, 27 VII 1965, Utah; E & e: Mains, 29 VIII 1947, Michigan; F: Kauffman, ?, Michigan; G & g: Solheim, 12 VII 1950, Wyoming. A, B, C, C_1, D, E, F, & G: habit sketches; a, b, d, e, & g: basidiospores; a' & d': cheilocystidia; a": basidium. (C, C_1, & D from colour transparencies; F from photograph; A & B from colour sketches; E & G from dried material.)

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Watling, Roy. 1965. Observations on the Bolbitiaceae 2. A conspectus of the family. Notes Roy. Bot. Gard. Edinb. 26: 289-323.

FUNARIA FLAVICANS, A MOSS NEW TO CANADA

Howard Crum and Wilfred Botham
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and R. R. 1, Cottam, Ontario

Although *Funaria flavicans* Mx. is no more than a weed in the southeastern United States, it is progressively less common northward, and its recent discovery in southern Canada is a distinct surprise. It was collected on the east side of Point Pelee in Essex County, Ontario, on sand near Lake Erie where wood had been burned (*Wilfred Botham 8*, May 7, 1967, MICH). Point Pelee is not far from southeastern Michigan, and the known distribution of the species elsewhere to the south indicates that *F. flavicans* may be confidently expected in Michigan as well.

It grows on soil (or occasionally brick or stonework, often in burned-over places, in gardens, pastures, woods, roadsides, and railroad grades) from New York to Oklahoma and south to the Gulf of Mexico. (Specifically, it is thus far known from Ala., Conn., Dela., Ga., Ill., Ind., Ky., La., Md., Miss., Mo., N. Y., N. C., Ohio, Okla., Ont., Penn., S. C., Tenn., Va., Washington D. C., W. Va.).

Although similar in a general way to the ubiquitous *Funaria hygrometrica*, *F. flavicans* is easily recognized by its setae which are scarcely hygroscopic, its nearly straight and only slightly asymmetric capsules becoming only moderately plicate on drying, and its inner peristome of emarginate or bluntly bilobed segments about one-quarter as long as the teeth of the outer peristome.

MICHIGAN PLANTS IN PRINT

New Literature Relating to Michigan Botany

This section lists new literature relating to Michigan Botany under four categories: A. Maps, Soils, Geography, Geology (new maps and selected bulletins or articles on soils and geology as these may be of use to field naturalists and students of plant distribution); B. Books, Bulletins, etc., and C. Journal Articles (listing, respectively, all separate publications and articles in other periodicals which cite Michigan specimens or include research based on plants of wild origin in Michigan; —not generally including work on cultivated plants nor strictly economic aspects of forestry, conservation, or agriculture); D. History, Biography, Exploration (travels and lives of persons with Michigan botanical connections). When the subject matter or relation to Michigan is not clear from the title, annotations are added in brackets. Readers are urged to call to the editor's attention any titles (1960 or later) which appear to have been overlooked—especially in less well known sources.

A. MAPS, SOILS, GEOGRAPHY, GEOLOGY

The following topographic maps for Michigan have been published by the U.S. Geological Survey, Washington, D.C. 20242, since the previous listing in our January, 1967, issue. All are 7 1/2-minute quadrangles (scale of 1:24,000 or about 2 1/2 inches to a mile). Maps are supplied with green overprint showing wooded areas unless request is made to the contrary. Standard topographic quadrangle maps are $ .50 each, and maps in the 1:250,000 series are $ .75 each, with a 20% discount on orders totalling $20.00 or more.

Following the name of the quadrangle, the county or counties in which it primarily lies are added in brackets in the list below:

Ann Arbor East [Washtenaw]
Ann Arbor West [Washtenaw]
Aurelius [Ingham]
Damon [Ogemaw]
Dimondale [Eaton]
Eaton Rapids [Eaton]
Hamburg [Livingston & Washtenaw]
Lansing North [Clinton]
Lansing South [Ingham]
Maple Rapids [Clinton]
Ogemaw Springs [Ogemaw]
Oregon [Monroe, plus Ohio]
(Replaces earlier Point Place)
Perrinton [Gratiot]
Pinckney [Livington & Washtenaw]
Pompeii [Gratiot]
Riley [Clinton]
Riverdale [Gratiot]
Rose City [Ogemaw]
St. Helen [Roscommon]
St. Helen NE [Ogemaw]
St. Helen NW [Roscommon]
St. Johns North [Clinton]
St. Johns South [Clinton]
Selkirk [Ogemaw]
South Lyon [Washtenaw, Livingston, & Oakland]
Sumner [Gratiot]
Vestaburg [Montcalm]
Wacousta [Clinton]

Slightly revised editions of the Milwaukee (NK 16-2) and Hancock (NL 16-1,2) sheets in the 1:250,000 series have been issued.

Bayley, R. W., C. E. Dutton, and C. A. Lamey. "1966" [1967]. Geology of the Menominee Iron-bearing District Dickinson County, Michigan and Florence and Marinette Counties, Wisconsin. U.S. Geol. Surv. Prof. Pap 513. 96 pp. + 4 pl. in pocket. $2.50 (U.S. Gov. Printing Off.). [Text largely on bedrock geology but with useful general information on the area (162 square miles), which includes the botanically interesting Quinnesec region. Three 1:24,000 topographic maps show the usual surface features, plus bedrock, including outcrops.]

Hough, Ashbel F. 1967. Twenty-five-year results of a red pine provenance study. For. Sci. 13: 156-166. [Includes map of Lake States showing "average annual

accumulation of normal average daily temperatures above 50°F ('growth degrees') and average January temperatures.'']

Wier, Kenneth L. 1967. Geology of the Kelso Junction Quadrangle Iron County, Michigan. U.S. Geol. Surv. Bull. 1226. 47 pp. + 3 pl. in pocket. $1.50 (U.S. Gov. Printing Off.). [Devoted chiefly to subsurface features, but with some information on surficial geology and 1:24,000 map including outcrops.]

Wiitala, S. W., T. G. Newport, and E. L. Skinner. 1967. Water Resources of the Marquette Iron Range Area, Michigan. U.S. Geol. Surv. Water-Supply Pap. 1842. 142 pp. + 4 pl. in pocket. $1.50 (U.S. Gov. Printing Off.). [In addition to data on ground-water supply, there is considerable information on lakes and streams in the 610 square mile area covered (one-third of Marquette Co., including all of the Carp and parts of the Chocolay, Michigamme, and Escanaba river basins); includes 1:96,000 map (not topographic) showing surface geology.]

Wyman, Donald, and Harrison L. Flint. 1967. Plant Hardiness Zone Maps. Arnoldia 27: 53-56 + map. $ .10. [Text discusses such maps and compares Arnold Arboretum map with that of USDA (noted in Mich. Bot. 6: 27. 1967). Color map indicates boundaries of 3 hardiness zones in Michigan, total of 10 in U.S. and southern Canada.]

B. BOOKS, BULLETINS, SPECIAL REPORTS, AND MISCELLANEOUS

Baxter, Dow V. 1967. Disease in Forest Plantations: Thief of Time. Cranbrook Inst. Sci. Bull. 51. 251 pp. $8.50. [Based in large part on experience from the Saginaw Forest, Washtenaw Co.; see review on p. 30.]

Braun, E. Lucy. 1967. The Monocotyledoneae Cat-tails to Orchids. Ohio State Univ. Press, Columbus. 464 pp. $10.00. [See review in Mich. Bot. 6: 184. 1967. Michigan is mentioned in the distribution of several species, particularly *Disporum maculatum*; and *Trillium cernuum* is drawn from a Michigan specimen.]

Hotchkiss, Neil. 1967. Underwater and Floating-Leaved Plants of the United States and Canada. U.S. Dep. Interior, Bur. Sport Fish. & Wildl., Resource Publ. 44. 124 pp. $ .65 (U.S. Gov. Printing Off.). [A guide, with rough sketches but no keys, to plants of both fresh and marine waters. Sometimes difficult problems (as in *Isoetes* and *Sparganium*) are avoided by only mentioning the species, and other times by over-enthusiastic ''lumping'' (most botanists would hesitate, e.g., to lump *Ranunculus gmelinii* and *R. flabellaris*, *Potamogeton berchtoldii* and *P. lateralis*, *P. foliosus* and *P. hillii*). Michigan is specifically mentioned in the distribution of four species.]

(Huron Mountain Wildlife Foundation). 1967. Report of Huron Mountain Wildlife Foundation—1955-1966 with Bibliography and Related Material. 96 pp. [Includes chronological list of botanical and other scientific work done in the Huron Mountains 1925-1966, annotated bibliography, and texts of reports by Aldo Leopold (1938), Michigan Natural Areas Council (1960-1962), and other documents related to concern of the Huron Mountain Club for the scientific values of its approximately 18,000 acres of wild land in Marquette Co.]

Johnson, Von J. 1966. Seasonal Fluctuation in Moisture Content of Pine Foliage. North Central For. Exp. Sta., U.S. For. Serv. Res. Note NC-11. [4] pp. [One of sources of data was jack and red pine needles from Manistee National Forest in Michigan.]

Lowe, Josiah L. 1966. Polyporaceae of North America The Genus Poria. St. Univ. Coll. For., Syracuse Univ., Tech. Publ. 90. 183 pp. $1.50 (Dept. Forest Extension, State Univ. College of Forestry, Syracuse, N.Y. 13210). [Many of the species are said to occur in Michigan; no detailed distribution data.]

Reid, Derek A. 1965. A Monograph of the Stipitate Stereoid Fungi. Nova Hedwigia Beih. 18. 382 pp. + 48 pl. $25.00 [Two species of *Cotylidia* are cited from Michigan localties.]

Thompson, Paul W. 1967. Vegetation and Common Plants of Sleeping Bear. Cranbrook Inst. Sci. Bull. 52. 47 pp. $1.50. [See review, Mich. Bot. 6: 175. 1967]

Wilce, Joan Hubbell. 1965. Section Complanata of the Genus Lycopodium. Nova Hedwigia Beih. 19. 233 pp. + 40 pl. $15.00. [Several species and hybrids in Michigan, supported by full citations and general distribution maps. Repeated apologies for use of an alleged invalid sectional name are unnecessary, as Section Complanata was published by Victorin 10 years before the requirement of a Latin diagnosis.]

C. JOURNAL ARTICLES

Allison, Leonard N. 1967. Beggar-Ticks cause mortality among fingerling Coho Salmon. Progressive Fish-Culturist 29: 113. [Fruit of *Bidens cernuus* embedded in gills and oral cavity of fish at Platte River Trout Rearing Station at Honor.]

Anderson, Gerald W., and David W. French. 1965. Western gall rust in the Lake States. For. Sci. 11: 139-141. [Found on jack pine in Hiawatha National Forest in Upper Peninsula.]

Baxter, Dow V. "1966" [1967*]. Fungus development from field to forest in pine plantings of 1904 and later. Pap. Mich. Acad. 51: 149-156. [Fungus establishment in plantings in Washtenaw Co.]

Bailey, Robert E. "1966" [1967*]. Postglacial pollen sequence in a bog of the Loesell Field Laboratory of Eastern Michigan University. Pap. Mich. Acad. 51: 167-174. [Study in Ypsilanti Tp., Washtenaw Co.]

Barnes, Burton V. 1967. Indications of possible mid-Cenozoic hybridization in the aspens of the Columbia Plateau. Rhodora 69: 70-81. [Includes comparisons with Michigan hybrids.]

Boneham, Roger F. 1967. Devonian Tasmanites from Michigan, Ontario, and northern Ohio. Pap. Mich. Acad. 52: 163-173. [Michigan locations for these fossils of green algae are cited in Alpena, Antrim, and Monroe counties.]

Brown, Robert Thorson. 1967. Influence of naturally occurring compounds on germination and growth of jack pine. Ecology 48: 542-546. [Effects of extracts of 56 plant species "commonly associated with jack pine" on germination of seeds from "northern Michigan" (Upper Peninsula). *Salix pellita*, one species which gave nearly complete inhibition, would (if correctly identified) be not only a significant range extension but also an unusual habitat if commonly associated with jack pine in the U.P.]

Brunett, Fel V. 1966. An archaeological survey of the Manistee River Basin: Sharon, Michigan to Sherman, Michigan. Mich. Archaeol. 12: 169-182. [Includes general observations on vegetation (also soils and history) of the valley.]

Church, George L. 1967. Pine Hills Elymus. Rhodora 69: 330-351. [Includes results of experimental crossings of Michigan *Hystrix* with Illinois *Elymus*.]

Church, George L. 1967. Taxonomic and genetic relationships of eastern North American species of Elymus with setaceous glumes. Rhodora 69: 121-162. [Includes a key to eastern N. A. species of *Elymus* and citation of two representative specimens of *E. wiegandii* from Michigan.]

Colingsworth, Roscoe F., Matthew H. Hohn, and Gary B. Collins. 1967. Postglacial physicochemical conditions of Vestaburg Bog, Montcalm County, Michigan, based on diatom analyses. Pap. Mich. Acad. 52: 19-30.

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*Although no new taxa of plants (only of insects and of fossil echinoids), for which exact date of publication must often be known, are described in Vol. 51 of the Papers of the Michigan Academy, the attention of bibliographers is called to the fact that mailing to most Academy members was on May 4, 1967—although authors did receive reprints prior to that date.

Cooke, Wm. Bridge. 1962. A taxonomic study in the "Black Yeasts." Mycopath. Mycol. Appl. 17: 1-43. [*Microstroma juglandis* cited from *Carya* in Michigan.]

Crum, Howard, and Norton G. Miller. 1967. Three propaguliferous Pohlias from Michigan. Bryologist 70: 118-119.

Culberson, William Louis, and Chicita F. Culberson. 1967. A new taxonomy for the Cetraria ciliaris group. Bryologist 70: 158-166. [Generalized distribution maps include occurrence in Michigan of 3 of the 4 species.]

Davis, H. A., Albert M. Fuller, and Tyreeca Davis. 1967. Contributions toward the revision of the Eubati of eastern North America. Castanea 32: 30-37. [This first installment of a revision of *Rubus* subgenus *Rubus* ("*Eubatus*," nom. illeg.) includes a key to sections and a treatment of section *Hispidi*, with references to type collections of *R. plus*, *R. kalamazooensis*, *R. compos*, and *R. distinctus* in Michigan (of which only *R. plus* is maintained).]

Dissing, Henry, and Morten Lange. 1967. Notes on the genus Helvella in North America. Mycologia 59: 349-360. [Type of *H. connivens* sp. nov. is from Cross Village, Emmet Co.; other specimens of this and of *H. stevensii* (including type) cited from Michigan.]

Forman, Richard T. T. 1967. New and uncommon Wisconsin mosses. Bryologist 70: 115-117. [Michigan records for several of the species are referred to.]

Getz, Lowell L. 1961. Temperatures in different vegetation types in southern Michigan. Jack-Pine Warbler 39: 132-147. [Data on maximum and minimum temperatures at different levels throughout the year in six vegetation types in Mud Lake Bog area, Washtenaw Co.]

Gilliam, Jeanne A., and Ronald O. Kapp. 1967. A post-Wisconsin pollen sequence from Vestaburg Bog, Montcalm County, Michigan. Pap. Mich. Acad. 52: 3-17.

Graham, Shirley A. 1966. The genera of Araliaceae in the southeastern United States. Jour. Arnold Arb. 47: 126-136. [A footnote by C. E. Wood mentions occurrence of *Oplopanax* on Isle Royale.]

Imshaug, Henry A., and Irwin M. Brodo. 1966. Biosystematic studies on Lecanora pallida and some related lichens in the Americas. Nova Hedwigia 12: 1-59 + 12 pl. [Includes full citations of many Michigan collections and distribution maps.]

Kapoor, B. M., and J. R. Beaudry. 1966. Studies on Solidago. VII. The taxonomic status of the taxa Brachychaeta, Brintonia, Chrysoma, Euthamia, Oligoneuron, and Petradoria in relation to Solidago. Canad. Jour. Genet. Cytol. 8: 422-443. [Includes chromosome count of 2n = 18 for *S. canadensis* var. *canadensis* from Sugar Island.]

Kawano, Shoichi, and Hugh H. Iltis. 1966. Cytotaxonomy of the genus Smilacina (Liliaceae) II. Chromosome morphology and evolutionary considerations of New World species. Cytologia 31: 12-28. [Material of *S. racemosa* from Misery Bay, Houghton Co., represents the octoploid race of that species.]

King, Dennis R., and George S. Hunt. 1967. Effect of carp on vegetation in a Lake Erie marsh. Jour. Wildlife Managem. 31: 181-188. [Includes vegetation map of study area in Monroe Co.]

Laing, Charles C. 1967. The ecology of Ammophila breviligulata. II. Genetic change as a factor in population decline on stable dunes. Ecology 77: 495-500. [One of the two sites from which experimental material was obtained was Little Sable Point, Oceana Co.]

Lentz, Paul L. 1967. Delineations of forest fungi. Several species of Deuteromycetes and a newly described Botryobasidium. Mycopath. Mycol. Appl. 32: 1-25. [*Oidium simile* cited from Barry Co.]

Lévesque, Lucien, et Pierre Dansereau. 1966. Études sur les violettes jaunes caulescentes de l'est de l'Amerique du Nord. I. Taxonomie, nomenclature, synonymie et bibliographie. Nat. Canad. 93: 489-569. [A massive bibliography

of literature citations, with generalized distribution maps showing *V. eriocarpa* throughout Michigan and *V. pubescens* absent from western 3/4 of Upper Peninsula. Both taxa in fact range throughout Michigan, as documented by Russell's maps published in 1965.]

Lombard, Frances F., and Robert L. Gilbertson. 1966. Poria luteoalba and some related species in North America. Mycologia 58: 827-845. [Two Michigan collections of *P. eupora* cited.]

Milanez, Adauto I., and E. S. Beneke. "1966" [1967*]. An unusual Saprolegnia from the Gull Lake area. Pap. Mich. Acad. 51: 175-182. [Plants close to *S. diclina* from Kalamazoo and Barry counties.]

Paterson, R. A. 1967. Benthic and planktonic phycomycetes from northern Michigan. Mycologia 59: 405-416. [Data from Grand Traverse Bay and Sturgeon Bay, Lake Michigan, and Douglas Lake.]

Pringle, James S. 1967. Taxonomy of Gentiana, section Pneumonanthae, in eastern North America. Brittonia 19: 1-32. [Includes citation of representative specimens and localities on distribution maps for 6 species in Michigan; two Marquette Co. specimens appear to be hybrids *G. linearis* x *rubricaulis*.]

Schneider, G., D. P. White, and R. L. Harlan. "1966" [1967*]. Soil moisture regime under old growth hardwoods. Pap. Mich. Acad. 51: 13-21. [Study in Tuomey Woodlot, MSU, Ingham Co.]

Smith, Alexander H. 1965. New and unusual basidiomycetes with comments on hyphal and spore wall reactions with Melzer's solution. Mycopath. Mycol. Appl. 26: 385-402. [*Xerocomus truncatus* Singer from Emerson (Chippewa Co.) described.]

Stone, William J. H., and Ralph J. Green, Jr. 1967. The epiphytology of spearmint rust in Indiana. Mycopath. Mycol. Appl. 31: 17-26. [One of 18 collections of *Puccinia menthae* studied came from 4n *M. arvensis* x 4n *M. sylvestris* from an unspecified Michigan locality.]

Thieret, John W. 1966. Synopsis of the genus Calamovilfa. Castanea 31: 145-152. [*C. longifolia* var. *magna* mapped around Lakes Huron and Michigan (omitting Lake Superior station); var. *longifolia* adventive in southwestern Michigan.]

Urie, Dean H. "1966" [1967*]. Forest cover in relation to water yields on outwash sand soils. Pap. Mich. Acad. 51: 3-11. [Studies in jack pine, red pine, oak, and lowland hardwood fojests in Manistee Co.]

Witmer, S. W. 1964. Butomus umbellatus L. in Indiana. Castanea 29: 117-119. [Mentions occurrence in 7 counties of Michigan.]

Zahner, Robert, and John R. Donnelly. 1967. Refining correlations of water deficits and radial growth in young red pine. Ecology 48: 525-530. [Data from plantations near Pellston.]

D. HISTORY, BIOGRAPHY, EXPLORATION

Anderson, Edgar. 1965. David M. Gates, the new director. Missouri Bot. Gard. Bull. 53(9): 1-7. [Sketch of Michigan-trained physicist with biological interests, including two photos of ecological field work in Michigan.]

Buell, Murray F. 1963. Eminent ecologist for 1963 [William S. Cooper]. Bull. Ecol. Soc. Am. 44: 108-109. [Biographical sketch of an Alma College graduate, author of classical ecological treatise on vegetation of Isle Royale.]

Dana, Samuel T. 1967. A Final Word, pp. ix-xi *in* Disease in Forest Plantations: Thief of Time, by Dow V. Baxter, Cranbrook Inst. Sci. Bull. 51. [A tribute to the late Prof. Baxter; see also Smith, below.]

Evers, Robert A. 1965. Arthur Gibson Vestal 1888-1964. Trans. Illinois Acad. 58: 77-81. [Vestal developed his interest in botany as a youth near Pentwater, Michigan; he spent the summer of 1913 working with H. A. Gleason at the University of Michigan Biological Station, near which "Vestal's Bog" bears his name.]

Graustein, Jeannette E. 1967. Thomas Nuttall Naturalist, Explorations in America 1808-1841. Harvard Univ. Press, Cambridge. 481 pp. $11.95. [Biography of naturalist who first seriously studied the Michigan flora; chapter 5 includes his journey through the Upper Great Lakes in 1810—on which further information is provided in Mich. Bot. 6: 81-94. 1967.]

Martin, W. E. 1965. Arthur Gibson Vestal 1888-1964. Bull. Ecol. Soc. Am. 46: 27-29. [Includes list of major publications; cf. Evers, above.]

Smith, Alexander H. 1967. Dow V. Baxter (1898-1965). Mycologia 59: 565-567. [Obituary of University of Michigan professor, authority on wood-decaying fungi, collector in Michigan, Alaska, and elsewhere.]

Sparrow, Frederick K. 1964. Robert M. Johns, 1928-1963. Mycologia 56: 309. [Brief sketch of 1958 Michigan Ph.D. whose mycological work in Michigan centered on Phycomycetes.]

Taylor, Mrs. J. Lee, and Mrs. Robert Turner, eds. 1967. The Nut Jar A Cookbook. Mich. Nut Growers Assoc. 132 pp. $2.50. [Includes a history of nut culture in Michigan; see review in Mich. Bot. 6: 178. 1967.]

Thackrey, Donald E. (ed.). 1967. Research Definitions and Reflections. Essays on the Occasion of The University of Michigan's Sesquicentennial. Univ. of Mich., Ann Arbor. 207 pp. $1.75. [Includes essays on fungi by F. K. Sparrow and on algae by W. R. Taylor, the latter a general historical discussion of algal research at the U. of M.]

Welch, Winona H. 1964. Truman G. Yuncker 1891-1964. Taxon 13: 189-192. [Dr. Yuncker was a native of Michigan and graduate of MSU.]

Review

DISEASE IN FOREST PLANTATIONS: THIEF OF TIME. By Dow V. Baxter. Cranbrook Institute of Science (Bulletin 51), Bloomfield Hills, Michigan. 1967. xviii + 251 pp. $8.50.

Those of us who remember back to the era of the 30's and the "CCC" days somehow received the impression that all one had to do to grow trees was to plant them and then wait for the crop to mature. If this idea still persists in anyone's mind, Dr. Dow Vawter Baxter's posthumus book should dispel the last vestiges of it. In fact after reading the book, one might wonder why any trees in a plantation survive. However, for anyone with a healthy interest in trees, I recommend this work as fascinating, not only because it is full of Baxter's superb photographs, but it is also written in his characteristically engaging style. Baxter, as his students in forest pathology were keenly aware, preferred to approach the problems of forest disease from an ecological standpoint, and this is the most valuable aspect of Disease in Forest Plantations—it focuses on the ecological aspects of having large areas of planted trees all the same age and all the same species, and their vulnerability to attack. I heartily recommend the book to all naturalists.

—Alexander H. Smith

Editorial Notes

The October number (Vol. 6, No. 4) was mailed October 25, 1967.

THANKS TO REVIEWERS. One of the chief functions of the members of the Editorial Board is to review manuscripts submitted for publication, considering botanical content, clarity of presentation, and suitability for this journal. Reviewers of individual papers are traditionally anonymous, but the editor takes this opportunity to express his appreciation not only to members of the Editorial Board (named on the inside front cover) but also the following, who have served as reviewers for one or more articles submitted for volumes 4-6: Drs. Burton V. Barnes, Charles B. Beck, W. S. Benninghoff, John E. Cantlon, Howard Crum, Margaret B. Davis, Francis C. Evans, Henry Imshaug, Peter B. Kaufman, Robert L. Shaffer, Helen V. Smith, Otto T. Solbrig, Ronald L. Stuckey, H. W. Vogelmann.

Publications of Interest

SPRING FLORA OF MINNESOTA Including Common Cultivated Plants. By Thomas Morley. Department of Botany, University of Minnesota, Minneapolis, 1966. 283 pp., wire-bound. $3.50 plus postage, from Nicholson Hall Bookstore, Univ. of Minnesota, Minneapolis 55455. From its concise, lucid introduction to its above-average glossary, this little flora has aroused a more enthusiastic response from the editor than any other he has seen in a long time. It is both sensible and up to date in regard to taxonomic and nomenclatural problems, and includes the common cultivated plants as well as the native and naturalized species which ordinarily bloom before June 7 in Minnesota (a total of 850 species). Keys and helpful additional comments are included, but no illustrations (except for those preceding the glossary, a county map, and a map of Minnesota vegetation types). Minnesota residents are extremely fortunate to have such a fine volume available. Michigan botanists will note the omission of such familiar spring species of our flora as *Cardamine douglassii, Tiarella cordifolia, Trillium erectum, Acer pensylvanicum*. The more northwestern flora, earlier cutoff date, and absence of illustrations make this flora perhaps a little less useful in Michigan than Fassett 's excellent Spring Flora of Wisconsin. But the more modern text, inclusion of cultivated plants, and greater number of grasses and sedges are decided advantages. We look forward eagerly to the anticipated hardcover edition contemplated by the Universiy of Minnesota Press!

HARVEST WITHOUT PLANTING Eating and Nibbling Off the Land. By Erika E. Gaertner. Published by the author, Chalk River, Ontario, 1967. 66 pp. $2.00 from the author or from Donald F. Runge, Ltd., 243 Pembroke St. W., Pembroke, Ontario. Those who like to nibble off the land will doubtless find some new recipes in this original compilation—unless they already have directions for Boiled Beaver Tail, Braised Muskrat in Tomato Sauce, Birch Cheesecake, Elderberry Fritters, Milkweed Bud Salad, Cat-tail Pollen Pancakes, Crayfish Bisque, and such delicacies.

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(*On the cover: Hedgehog or Medusa-head fungus,* Hericium erinaceus, *photographed on a white oak trunk at the Rose Lake Wildlife Experiment Station, Clinton Co., Michigan, by Peter Stettenheim, September 27, 1966. The white threads across the bottom are spider webs laden with spores from the fungus.*)

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Articles and notes dealing with any phase of botany relating to the Upper Great Lakes Region may be sent to the editor in chief. The attention of authors preparing manuscripts is called to "Information for Authors" (Vol. 6, p. 202; reprints available from the editor).

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Membership in the Michigan Botanical Club is open to anyone interested in its aims: conservation of all native plants; education of the public to appreciate and preserve plant life; sponsorship of research and publication on the plant life of the State; sponsorship of legislation to promote the preservation of Michigan native flora and to establish suitable sanctuaries and natural areas; and cooperation in programs concerned with the wise use and conservation of all natural resources and scenic features.

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A PRELIMINARY STUDY OF *CLAVARIADELPHUS* IN NORTH AMERICA

Virginia L. Wells and Phyllis E. Kempton
Anchorage, Alaska[1]

INTRODUCTION

It was our original intention to include Alaskan species of *Clavariadelphus* in a series of papers concerning Alaskan fungi, the first two of which have already been published (1965, 1967). But it was soon apparent that our species could not be properly placed until a critical examination of all North American species of this genus was undertaken. This paper is the result of our four-year study of the *Clavariadelphus* flora of North America.

Clavariadelphus was originally erected by Donk (1933) to separate three species, *C. pistillaris* (type), *C. truncatus,* and *C. ligula,* from the other clavarioid fungi. The genus received little attention until Doty (1948) included it in his key, further delimiting it to those species which turn green with $FeSO_4$. Corner (1950) divided the genus into three subgenera: *Eu-Clavariadelphus, Cantharellopsis,* and *Typhulopsis.* The species Corner placed in subgenus *Typhulopsis* (*C. junceus* and *C. fistulosus*) are not under consideration in this paper because we were unable to obtain sufficient collections to examine and we feel that a more critical study of them is necessary to determine their correct generic assignment.

Corner's other subgenera, *Eu-Clavariadelphus* and *Cantharellopsis,* are based mainly on the size, shape, and degree of apical sterility or fertility of the fruitbodies and, in our opinion, are artificial divisions. We believe that the genus *Clavariadelphus* is composed of two distinct series of species with some overlapping microscopic and macroscopic features, and that the genus should be divided by a more basic character—the shape of the spores. We are therefore proposing that the genus be divided into two sections: Section *Clavariadelphus,* with spores two to two-and-a-half times as long as broad; and Section *Ligula,* with spores three or more times as long as broad.

Because we have had only limited use of standard color charts, most of the colors given in the descriptions are our own color concepts. Where color terms are enclosed in quotation marks, they represent Ridgeway's colors used by other authors or collectors.

All Alaskan collections are stored in the Wells-Kempton (W/K) private herbarium at Anchorage, Alaska. The following abbreviations are used in citing collections from other herbaria:

CINC—University of Cincinnati
DAOM—Dept. of Agriculture, Ottawa: Mycological Herbarium
MICH—University of Michigan

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[1]327 Fifth Ave. (VLW) & 1020 H St. (PEK).

RHP—Ronald H. Petersen, private herbarium
TENN—University of Tennessee
NCU—University of North Carolina
RM—University of Wyoming.

ACKNOWLEDGMENTS

We wish to thank the following people for their generosity in supplying specimens and information critically needed for this study: Dr. J. Walton Groves and Dr. J. A. Parmalee of the Canada Department of Agriculture, Dr. Ronald H. Petersen and Dr. L. R. Hesler of the University of Tennessee, Dr. C. R. Leathers of Arizona State University, Dr. J. B. Bozeman of the University of North Carolina, Dr. R. L. Shaffer of the University of Michigan, Dr. Clark T. Rogerson of the New York Botanical Garden, Dr. Margaret Fulford of the University of Cincinnati, and Dr. W. G. Solheim of the University of Wyoming. We are particularly indebted to Dr. A. H. Smith of the University of Michigan for his encouragement, advice, and general assistance throughout the research and preparation of this paper. We also wish to acknowledge financial support from the National Science Foundation (Grant GB 4634) for field work and publication expenses during the latter part of this study.

MACROSCOPIC CHARACTERS

Most species of *Clavariadelphus* are rather large in comparison with other simple clavarioid fungi. The size of the fruitbody is of some taxonomic value in distinguishing between species but, of course, is not absolute. The shape of mature fruitbodies, however, is of more constant value as a distinguishing feature. All young fruitbodies are typically cylindrical and obtuse to acute at the apex; but with age, some species become clavately inflated in the upper part, others become apically truncated, and one species (*C. mucronatus*) is both truncated and mucronate. In all species the hymenial surface is smooth but becomes longitudinally rugulose in age. All are typically simple and unbranched although they may have short branches or irregularities on or near their apices, and may grow connately if in close contact during development.

The basic colors of all species are yellow to buff to alutaceous, tan, or vinaceous-brown but shades of orange, pink, green, or lilac may occur and are sometimes constant enough to be used as diagnostic features at the species level. The bases of the fruitbodies are pallid to whitish but the color difference between the upper and lower parts is gradual and of no specific value. As far as is now known, only one species (*C. pistillaris*) stains with age or bruising.

The color of the fresh context is white to pallid ochraceous and more or less unchanging except for *C. pistillaris* which becomes vinaceous to brown when cut or bruised. The flesh of all young fruitbodies is firm and solid at first, becoming softer and more floccose with maturity, and occasionally collapses to produce a hollow or perforation at the apex in extreme age. When dried, the texture of the fruitbodies is fragile-brittle and specimens are easily crushed or shattered in storage if not adequately protected.

As far as we know, no species of *Clavariadelphus* has an odor distinctive enough to be used as an identifying character but taste, bitter or sweet, is a distinctive and constant feature in some species.

We believe that the spore deposit color, whether white or ochraceous, is an important diagnostic character at the species level and is essential in cases where other differentiating features such as spore size, fruitbody color, habitat, etc. are nearly identical. We have not been able to detect any change in spore deposit color, either fading or darkening, after drying or storing over a period of years.

We consider it important to know the following macroscopic features of fresh specimens in order to properly place species of *Clavariadelphus:* spore deposit color, color and color-changes of fruitbody and context, habit and habitat, size and shape of the fruitbody, and the taste.

MACROCHEMICAL REACTIONS

The chemical solutions employed during this study were 10% $FeSO_4$, 15% KOH, 28% NH_4OH, and 2% phenol.

In testing fresh material, solutions were applied directly to the various parts of the fruitbody. With dried material, small sections of hymenium and flesh were first dipped in either methanol or isopropyl alcohol to act as a wetting agent, then placed on a glass slide and a drop of the testing solution applied. The reactions to the above-mentioned chemicals are included in the descriptions of the species, but some additional data are worth mentioning.

Doty (1948), in his key to the genera of clavarioid fungi, used the green reaction to $FeSO_4$ as a generic character of *Clavariadelphus.* We have found this reaction to be constant in the material we have studied although, in contrast to Doty's thirty seconds, we found that it may take from thirty seconds to three minutes for the reaction to be visible. The shade and intensity of the color varies considerably, not only between species, but also between individual fruitbodies of the same species. The color may be pale to deep forest green, olive, or gray-green. On dried material, we found the reaction to be strongest on the context of the fruitbody and frequently intense enough to cause the mounting medium to turn green.

Except for *C. unicolor,* the surface of all truncated species in section *Clavariadelphus* turned pink to red with KOH. However, one anomalous collection of either *C. truncatus* or *C. borealis* (*Smith 46253,* MICH), from which no spore deposit had been taken, gave a surprising negative KOH reaction. Subsequent examination showed all the fruitbodies in that collection to be sterile. The deviation of chemical reaction appears to be related to spore production but the problem requires further research.

To date, phenol has not produced a color change when applied to dried material, but fresh fruitbodies of some species do stain strongly vinaceous on all parts where phenol is applied. The phenol reaction may prove to be a valuable character, but further testing on fresh specimens will be necessary before the extent of its usefulness can be fully determined.

DISTRIBUTION, HABITAT, AND HABIT

We feel that much of North America has not been investigated sufficiently to permit establishment of actual distributional patterns for many species of *Clavariadelphus.* However, with the exception of *C. unicolor* which is known

primarily from southeastern United States, all North American species appear to be more common in northern regions or at high altitudes in southern regions. While the fruiting season varies from one part of the continent to another, all species are reported as autumnal.

The members of section *Ligula* are characterized by their densely gregarious manner of growth on matted needles and debris of coniferous trees. On the other hand, those in section *Clavariadelphus* do not share either a common habitat or manner of growth. Some species show a preference for predominantly deciduous woods while others have been found only in coniferous forests. Their manner of growth can be described variously as solitary, gregarious, cespitose, or subfastigiate. Some of the species in this latter section are little known, and further collecting may give more habit and habitat information for them than is now recorded.

MICROSCOPIC CHARACTERS

Most of the microscopic characters of *Clavariadelphus* species are rather monotonous in their similarity. For example, spores in those of both sections are hyaline with yellow refractive oil drops or a yellow granulose content (KOH), inamyloid, unicolorous in cotton blue, smooth, thin-walled, and relatively large, mostly over 8μ long. However, the shape of the spores is distinctive enough to divide the genus into the two sections we are proposing. In section *Clavariadelphus,* the spores are ellipsoid, broadly ellipsoid, or oblong, mostly equilateral, and are about two to two-and-a-half times as long as they are broad. In section *Ligula,* the spores are narrowly ellipsoid to "boletoid," the longer ones depressed on the dorsal side and ventricose on the ventral side giving them a characteristic "sway-backed" appearance in profile, and they are typically three to five times as long as they are broad.

Since spore deposits were seldom present with herbarium collections used for this study, we were concerned as to whether spores taken from dried specimens would measure differently from spores of a deposit. After numerous examinations of our own collections, we concluded that there is no appreciable difference in size between the two; nor could we find any difference in spore size between those mounted in water from a fresh deposit and a KOH mount from the same deposit after it had been dried.

Corner (1950) used the thickening in depth of the hymenium as a generic character for *Clavariadelphus.* In connection with the "*C. pistillaris*" he examined, he reported, "hymenium gradually thickening from 100μ to 300μ deep in old specimens, very compact, with many included spores." In the various species we have examined, there is a constant proliferation of basidia for the full life of the fruitbody, with old basidia collapsing after spore discharge and being replaced by new basidia in various stages of development, but we have found no evidence that this contributes to a measurable increase in the depth of the hymenium and we rarely found spores trapped within the hymenium.

The basidia are narrowly clavate, usually filled with a yellow refractive granulose content or oil drops, and are very long—a character Donk (1933) used in separating *Clavariadelphus* from *Clavaria.* In our examinations, we have

discovered that the basidia vary in length as much as 20μ to 60μ from one area of the fruitbody to another, a factor undoubtedly contributing to the disparity in basidial measurements noted throughout the literature.

The longest basidia occur on the upper one-half to two-thirds of the fruitbody, or just below the margin of the truncation of some species. The shortest basidia occur on the apex of some species, on the margin of some truncated species, or near the base of the fruitbody, and are frequently distorted or aborted. The sterigmata are straight on the longer basidia but tend to be malformed on the shorter basidia in that they may branch, grow confluently, or be obtuse and peg-like (Fig. 1). Corner (1950) used the term "caulocystidia" to describe the sterile clavate cells he found near the base of the "*C. pistillaris*" he examined. Similar cells are frequently present near the base of all *Clavariadelphus* fruitbodies but we prefer to call them "caulobasidia" because they are not always sterile (Fig. 2).

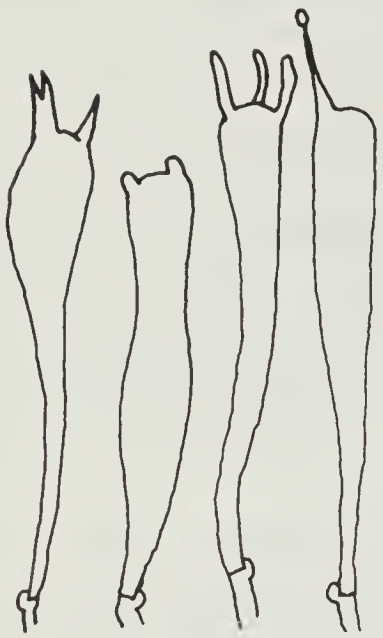
The basidia are predominantly 4-spored, but some 2-spored basidia are nearly always present in the hymenium, and 1- or 3-spored basidia are not unusual near the fruitbody base or on the marginal area of some truncated species. The basidia collapse after discharging the spores but we have never seen them become secondarily septate as reported by Petersen (1967) in *Clavulina.*

We consider cystidia to be absent from species in this genus even though there are some sterile elements present on the margins of some truncated species which might qualify for the terms "pseudoparaphyses" or "cystidioles" in the sense of Singer and Gamundí (1963). But since the margin of the truncation is a transitional zone between the fertile hymenium of the sides and the sterile surface of the apex, one should expect to find an immixture of fertile and sterile elements in this area.

The subhymenium is composed of hyaline to yellow, narrow, interwoven hyphae which tenaciously cling to the hymenial elements and join them to the tramal hyphae. We feel that it is the presence or absence of the subhymenium, or the degree to which it is developed, that plays a vital part in shaping the fruitbody. On the sides, where the subhymenium is strongly developed, there is little lateral expansion. But in some species where the subhymenium is weakly or irregularly developed near the apex, that area may expand thus becoming clavate or lobed or nearly convoluted. On truncated fruitbodies where the subhymenium is absent over the apex, there is relatively unrestricted lateral growth.

This constricting influence of the subhymenium is readily demonstrated when attempts are made to crush out the hymenium under a cover slip. Pressure causes the hymenial elements to become arranged into "fans" or "rosettes" with their bases firmly tied together by the subhymenial hyphae. Further pressure may result in the hymenial elements breaking off above their connection with the subhymenium, leaving the subhymenium more or less intact. The bond between the subhymenium and the trama is not as strong and pressure on the cover slip will cause the subhymenium to separate from the tramal hyphae.

All tramal hyphae are hyaline to yellowish, or occasionally with oleaginous content, smooth, and inamyloid. Initially they are narrow, moderately thick-walled and arranged more or less longitudinally parallel, but with age they



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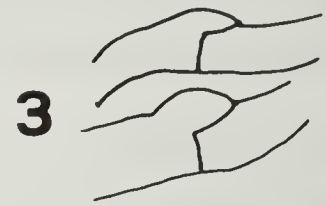

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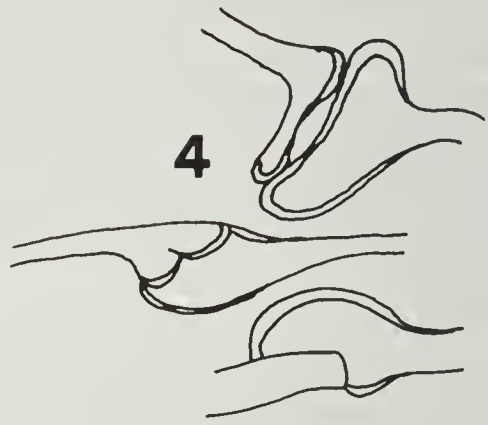

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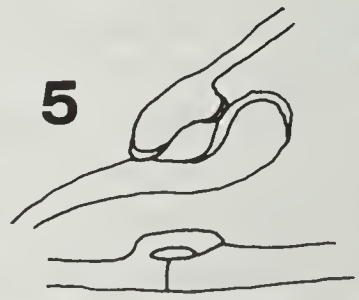

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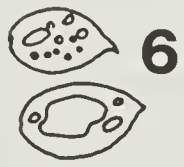

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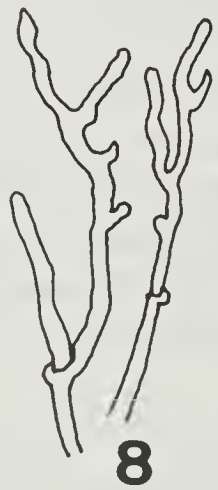

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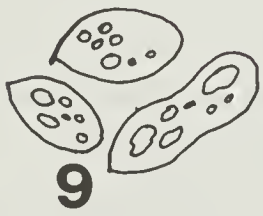

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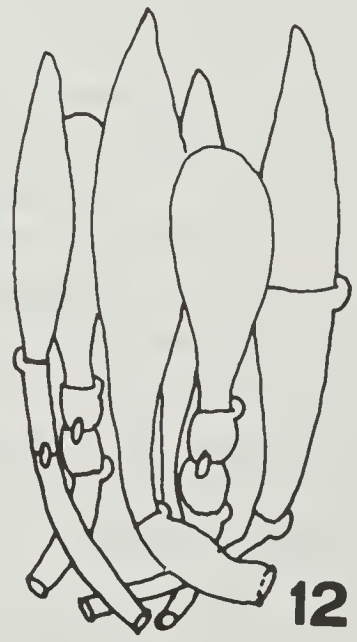

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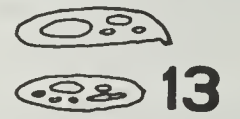

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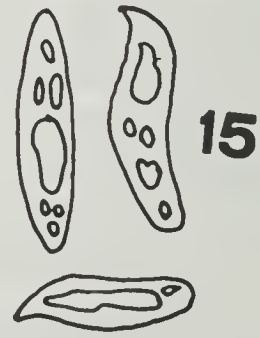

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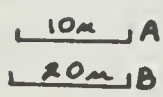

become inflated, thin-walled, and interwoven in the center of the fruitbody while remaining parallel in the base and under the subhymenium along the sides of the fruitbody.

The mycelial hyphae occur in fascicles which macroscopically appear as whitish strands binding the substratum into clumps, pads, or mats. These vegetative hyphae have thin to thick walls which are either smooth or decorated with yellow crystals as seen when mounted in KOH or water. The crystals are of varying shapes and distribution: They may be up to 7.5μ long, aciculate, and lying at various angles across the hyphae; irregularly angular to subangular, 1.5-4.5μ diam, and arranged in rosette-like clusters; or they may be scattered with no particular pattern and of both sizes and shapes. At times they may become dislodged from the walls, leaving sections of the hyphae bare. We have not found either the shape or the distribution of the crystals to be of any taxonomic value at the species level.

Clamp connections are abundantly present in all parts of the fruitbody and the mycelium, and occur as three different types: 1. Thin-walled clamp connections in which the diameter of the clamp is approximately the same as the diameter of the connected hypha (Fig. 3). This type is the most common. 2. "Inflated" clamp connections in which the diameter of the clamp is two to four times that of the connected hypha, and in which the walls are thick (1-1.5μ) and yellow refractive as seen when mounted in KOH (Fig. 4). These are most frequently found in the basal regions of the fruitbody and on the mycelium. 3. "Medallion" clamp connections in which the clamp branch forms a free arc or loop over the septum (Fig. 5). This type may be found scattered throughout the upper part of the fruitbodies but is less common than the preceding types.

We are including ten species in this paper, four of which are new. It is interesting to note that of these four, two have previously been described under names of older species: *C. cokeri* was described as *Clavaria pistillaris* by Coker (1923) and *C. mucronatus* as *Clavaria unicolor* by Doty (1944).

CLAVARIADELPHUS Donk

Fruitbodies typically simple (exceptionally with one or several short branches at the apex), small to relatively large (2-20 cm tall), clavate, subventricose, ligulate or turbinate, or rugose to irregularly contorted; apices acute to obtuse, truncate, or occasionally mucronate; yellow, ochraceous, alutaceous, tan, or buff but some species with red, pink, orange, olive, gray, green, or lilac also present, color sometimes changing markedly with age or bruising, base pallid but not sharply delimited; surface smooth becoming longitudinally rugose with age;

Figs. 1-15. *Clavariadelphus.* 1. Basidia with malformed sterigmata. 2. Caulobasidia. 3. Common thin-walled clamp connections. 4. Inflated clamp connections. 5. "Medallion" clamp connections. 6. Spores of *C. subfastigiatus.* 7. Tubular to clavate terminal cells on sterile apex of *C. unicolor.* 8. Flexuous to branched terminal cells on sterile apex of *C. unicolor.* 9. Spores of *C. lovejoyae.* 10. Clavate to subventricose terminal cells on sterile apex of *C. lovejoyae.* 11. Spores of *C. borealis.* 12. Fusoid-ventricose terminal cells on sterile apex of *C. borealis.* 13. Spores of *C. mucronatus.* 14. Spores of *C. ligula.* 15. Spores of *C. sachalinensis.* Figs. 3, 4, 5, 6, 9, 11, 13, 14, and 15, scale A. Figs. 1, 2, 7, 8, 10, and 12, scale B.

hymenium covering entire fruitbody except the base or absent also on the apex of some truncated species; flesh firm becoming spongy and floccose, whitish, sometimes staining when cut, green with $FeSO_4$; habit gregarious, solitary, or subfastigiate, in deciduous or coniferous woods. Spores white or ochraceous in deposit, oblong, broadly ellipsoid, or narrowly ellipsoid to boletoid, smooth, thin-walled, hyaline with yellowish granular content or yellowish oil drops, inamyloid. Basidia predominantly 4-spored but 2-spored ones usually also present, long and narrowly clavate. Cystidia none. Hyphae thin to moderately thick-walled, smooth to obscurely roughened (incrusted with crystals on mycelium), oleiferous hyphae sometimes present, clamp connections constantly present. Type species: *Clavariadelphus pistillaris* (Fr.) Donk.

KEY TO THE SECTIONS

A. Spores oblong, ellipsoid, or broadly ellipsoid with the length two times the width or shorter . . . . . Section *Clavariadelphus*
A. Spores narrowly ellipsoid to "boletoid" with the length three times the width or longer . . . . . Section *Ligula*

Section CLAVARIADELPHUS

KEY TO THE SPECIES

1. Spore deposit ochraceous; fruitbodies truncate; in coniferous woods . . . 1. *C. truncatus*
1. Spore deposit white; fruitbodies clavate, truncate, or irregularly flattened; solitary, gregarious, or fastigiate; in deciduous or coniferous woods 2
   2. Fruitbodies clavate; scattered to gregarious in deciduous woods; flesh and hymenium staining vinaceous-brown with age or bruising; taste often bitter . . . . . 2. *C. pistillaris*
   2. Not as above 3
3. Fruitbodies fascicled to subfastigiate at the base, clavate, subclavate, or irregularly flattened; in coniferous woods 4
3. Fruitbodies truncate; solitary or gregarious; in coniferous or deciduous woods 5
   4. Fruitbodies pallid at first becoming light cinnamon or brownish-orange, the apex obtuse . . . . . 3. *C. subfastigiatus*
   4. Fruitbodies pink at first becoming alutaceous, the apex acute at first but becoming obtuse or flattened and antler-like . . . . . 4. *C. cokeri*
5. Fruitbodies pink to lilac at first becoming alutaceous; in deciduous woods; typically in southeastern United States . . . . . 5. *C. unicolor*
5. Not as above 6
   6. Apex of fruitbody red; spores 11-17μ long . . . . . 6. *C. lovejoyae*
   6. Apex of fruitbody yellow-orange; spores 9-11μ long . . . . . 7. *C. borealis*

1. *Clavariadelphus truncatus* (Quél.) Donk, Rev. Niederl. Homobas. Aphyll. 2:73. 1933.

   Clavaria truncata Quélet, Enchir. Fung. p. 221. 1886.
   Craterellus pistillaris Fries, Epicr. Syst. Mycol. p. 534. 1838.
   Not *Clavaria truncata* Lovejoy, Bot. Gaz. 50:385. 1910.

The following macroscopic description is adapted from Leathers' (1955) description with additional notes provided by Dr. A. H. Smith.

Fruitbody 9-15 cm tall, 4-6 cm diam. at the apex, simple, turbinate, or clavate with a broadly convex apex which becomes truncated and often slightly depressed at disc with age, margin of the truncation recurved, gradually attenuated downwards to a usually bulbous (1-2.5 cm diam.) but not sharply delimited base immersed in a mat of white mycelium; pinkish-brown "onion skin pink" to "vinaceous tawny," drying deep vinaceous-brown "hessian brown," apex bright to golden yellow when fresh "capucine yellow" to "orange buff," drying to "clay color;" surface smooth at the base becoming rugulose upward, at times almost veined; context white, drying to pale cream "pinkish buff," solid, spongy becoming fibrillose on drying, green in ferric sulphate, odor none, taste very sweet. Spore deposit pale ochraceous.

Sparsely gregarious to cespitose on conifer needles, Aug.-Oct.

The following microscopic data are from our examination of *Leathers 409* (MICH) labeled *Clavaria truncata:*

Spores 9-11.5 x 6-7μ, broadly ellipsoid, hyaline with yellow oil drops, walls smooth and thin. Hymenium present only on the sides of the fruitbody. Basidia narrowly clavate, 92-115 x 10.5-12.5μ with sterigmata up to 7.5μ long, mostly 4-spored but 1- and 2-spored ones also present. Cystidia none. Subhymenium interwoven of yellowish hyphae 2.3-3μ diam. Truncate apex sterile or with a few scattered basidia; epicutis a hymeniform layer of hyaline to yellowish, thin-walled, clavate to ventricose cells 50-80 x 10-17μ. Tramal hyphae yellowish, smooth, 4.5-7.5μ diam, parallel in the base and under the hymenium, interwoven in the center of the fruitbody. Clamp connections present.

Material studied: MICHIGAN: Leathers 409 (MICH).

Observations: Since we have never seen fresh material of *Clavariadelphus truncatus,* we have relied heavily on Leathers' (1955) macroscopic description. Unfortunately, the collections from which Leathers drew his description no longer include spore deposits but he was emphatic in stating that the deposits were ochraceous.

Except for the spore deposit color, *C. truncatus* appears to be identical with *C. borealis.* However, this close relationship between species is not unusual in *Clavariadelphus.* A similar situation occurs between *C. pistillaris* (Fr.) Donk and *C. pistillaris* sensu Corner (1950) and again, between *C. ligula* and *C. sachalinensis,* although in these latter two cases there is also a difference in spore size.

Further field work will be necessary before the geographical range of *C. truncatus* can be charted. It is possible that many collections we examined during the course of this study were actually *C. truncatus* but since spore deposits were lacking, these collections have not been cited in this paper. It is also possible that further field work may show differences of which we are now unaware between *C. truncatus* and *C. borealis.*

2. *Clavariadelphus pistillaris* (Fr.) Donk, Rev. Niederl. Homobas. Aphyll. 2:73; 1933.

Clavaria pistillaris Linnaeus ex Fries, Syst. Mycol. 1:477. 1821.
Not *Clavariadelphus pistillaris* sensu Corner, Ann. Bot. Mem. 1:279-281. 1950.

Fruitbody 6-15 (-20) cm tall, 8-30 (-45) mm diam. near the apex, simple, cylindrical becoming subventricose to clavate, apex usually rounded and frequently inflated with age, gradually narrowing below to a rather deeply inserted base; at first whitish with a yellow apex, soon becoming ochraceous to ochraceous-brown overall, staining brown to vinaceous-brown with age or handling, base remaining whitish at all ages but not sharply delimited; moist to dry, unpolished, smooth becoming longitudinally rugulose; context white, staining brown to vinaceous-brown when cut, firm becoming floccose, odor none, taste mild to bitter.

Chemical reactions: Fresh material: $FeSO_4$—all parts greenish; KOH—all parts negative or hymenium yellow to orange; phenol—all parts dark vinaceous-brown. Dried material: $FeSO_4$—all parts dark green; KOH—all parts negative.

Spore deposit white. Spores (7.5-) 9-13.8 (-16) x 4.5-7.5μ, ellipsoid to oblong, hyaline with yellow oil drops, walls thin and smooth. Hymenium present on sides and apex of the fruitbody. Basidia narrowly clavate, (60-) 75-130 x 7.5-13 (-15)μ with sterigmata up to 11μ long, mostly 4-spored but 2-spored ones also frequently present. Cystidia none. Subhymenium interwoven of hyaline to yellowish hyphae 2-4.5 (-5.5)μ diam. Tramal hyphae hyaline to yellowish, 3-14μ diam., walls smooth to obscurely roughened, thin to slightly thickened, parallel in the base and adjacent to the hymenium, interwoven in the center of the fruitbody. Clamp connections present.

Gregarious to scattered in predominantly deciduous woods, autumn to early winter.

Material studied: United States: ALASKA: Fairbanks, Wells & Kempton 8/15/64-10, 8/18/64-8, 8/26/65-14, 8/26/65-15, 8/26/65-21 (W/K); Palmer, E. Wiebe 8/28/67-22 (W/K). CALIFORNIA: Trinity Co., Lanphere 12-6-62 (MICH); Crescent City, Smith 55916 (MICH); San Francisco, Whited 20 (MICH). IDAHO: Nordman, Smith 54566 (MICH). MAINE: Madawaska Lake, Bigelow 4095 (MICH). MICHIGAN: Pinckney, Smith 64185 (MICH); Oakland Co., Smith 7012 (MICH); Haven Hill, Smith 64300 (MICH); Jackson Co., Shaffer 2604 (MICH); Pellston, Thiers 4394 (MICH). NORTH CAROLINA: Macon Co., Rogerson C266 (RHP), Petersen C948 (RHP); Transylvania Co., Petersen C475 (RHP); Thomas Ridge, A. J. S[harp] 8205 (TENN); Cataloochee, Bain 8396 (TENN); Linville Falls, Totten 5759 (NCU); Chapel Hill, Coker 13960 (NCU), Burnham 68 (NCU), Honeycutt 14068 (NCU); Highlands, Jones 13101 (NCU). OREGON: Grants Pass, Smith 55799, 56045, 56046 (MICH). TENNESSEE: Knox Co., S. L. Wallace 6543 (TENN); Nales Creek, Hesler 22939 (TENN). VERMONT: Windham Co., Shaffer 3510 (MICH). VIRGINIA: Mt. Lake, Meyer 14706 (TENN). WASHINGTON: Mt. Rainier Nat. Park, Smith 31663 (MICH). Canada: NOVA SCOTIA: Kentville, Harrison 95904, 111226 (DAOM). QUEBEC: Drayton F5713 (DAOM); Groves and Pennoyer 54146 (DAOM).

Observations: In this paper, we are using Donk's (1933) concept of *C. pistillaris* because the spore size he gives for this species ([8-] 10-16 x [4-] 5-7.5μ) is in agreement with that of collections found in North America.

We could not accept Corner's (1950) concept of *C. pistillaris* because he gave a much broader spore size (12-15 x 7-10μ), and there is a strong indication (Cotton and Wakefield, 1919) that the spore deposit of British material is ochraceous whereas all North American collections are reported to have a white spore deposit.

During the course of this study, we examined several collections which obviously are related to *C. pistillaris* but which we could not describe in this paper because of the lack of adequate field notes and spore deposits.

3. *Clavariadelphus subfastigiatus* Wells & Kempton, sp. nov.

Fructificatio 4-9 cm alta, 5-11 (-25) mm diam. ad apicem, simplex, crescens in fasciculis basibus subfastigiatis, cylindrica demum subventricosa vel subclavata, interdum complanata; diluta cinnamomea, ad basim pallens; apex obtusus, fertilis; laevis demum longitudinaliter rugulosa; contextus albidus, firmus demum floccosus, sapor initio amarus demum nullus. Sporae in cumulo albae, 8.5-10.7 (-12) x 5.6-6.5μ, late ellipticae. Cystidia nulla. Fibulae praesentes. In sylvis coniferae. TYPUS: Wells et Kempton 10/8/66-3. Salmon River Campground, Mt. Hood, Oregon (W/K).

Fruitbody 4-9 cm tall, 5-11 (-25) mm diam. at the broadest part, occuring in clusters, simple or occasionally connate at the base, cylindrical becoming subventricose to subclavate, occasionally flattened, apices obtuse; primordia pallid flesh-color becoming light cinnamon to dark ochraceous-flesh or brownish-orange, paler toward the base, apices concolorous; moist to dry, unpolished, smooth becoming rugulose, base pallid pruinose, with rather stout white rhizomorphs; context whitish, slowly and slightly vinaceous when cut or bruised, solid, longitudinally fibrous at first becoming subfloccose, odor none, taste slightly to moderately bitter at first but soon fading to mild.

Chemical reactions: Fresh material: $FeSO_4$—all parts weakly green; KOH—hymenium forest green fading to yellow-green, context yellow; NH_4OH—hymenium weakly green with fumes, yellowish with solution; phenol—all parts dark vinaceous. Dried material: $FeSO_4$—all parts blackish-green; KOH—all parts negative.

Spore deposit white. Spores 8.5-10.7 (-12) x 5.6-6.5μ, ellipsoid, hyaline with one to several yellow oil drops, walls thin and smooth (Fig. 6). Hymenium present on sides and apex of the fruitbody. Basidia narrowly clavate, 84-112 (-131) x (7.5-) 8.5-11μ with sterigmata up to 9.2μ long, mostly 4-spored but some 2-spored ones usually also present. Cystidia none. Subhymenium 25-75μ thick, interwoven of hyaline to yellow hyphae 2.5-3.5 (-11)μ diam. Tramal hyphae hyaline to yellowish, 3-7.5 (-9.5)μ diam., walls smooth to obscurely roughened, thin to slightly thickened, longitudinally parallel in the base and under the hymenium, interwoven in the center of the fruitbody. Clamp connections present.

Gregarious in clusters of 6-20 fruitbodies, rarely singly, on well decayed humus of coniferous woods, Oct.

Material studied: OREGON: Salmon River Campground, Mt. Hood, Wells & Kempton 10/8/66-3 (Type), 10/8/66-4 (W/K).

Observations: A few of the fruitbodies in the type collection have acute, shriveled, and blackened apices which we attribute to adverse weather conditions, probably freezing, but the majority have normally rounded and concolorous apices.

C. subfastigiatus seems to be most closely related to *C. cokeri* from which it differs in color, slightly broader spores, and possibly in the structure of the subhymenium. The depth of the subhymenium is given in the description of *C. subfastigiatus* because it appeared to be broader and more distinctive than in any other *Clavariadelphus* species we have examined. We feel that more collections will have to be studied before this subhymenial structure can be evaluated as a taxonomic feature.

4. *Clavariadelphus cokeri* Wells & Kempton, sp. nov.

Fructificatio usque ad 20 cm alta, simplex, crescens in fasciculis basibus confertae et penitus insertae, cylindrica demum anguste clavata, interdum complanata; apex subacutus demum obtusus, interdum brevis ramosus; rosea demum alutacea; laevis demum longitudinaliter rugulosa; contextus albidus, firmus demum floccosus, sapor leviter piperatus. Sporae in cumulo albae, 9.4-11.3 x 4.7-5 (-5.6)μ, oblongae vel subellipticae. Cystidia nulla. Fibulae praesentes. In sylvis coniferae. TYPUS: W. C. Coker R. 27, September 6, 1919, Redding, Connecticut (NCU).

Fruitbody up to 20 cm tall, occurring in clusters with the bases crowded and deeply inserted, cylindrical and subacute at the apices at first, becoming narrowly clavate with an obtuse apex, sometimes flattened or branched like an antler; smooth becoming rugosely channeled; dull rosy when young becoming rosy-buff to alutaceous, the tip deepest colored, base whitish; context white, firm becoming floccose, odor none, taste pleasant but mildly peppery.

Chemical reactions: Dried material: $FeSO_4$—very obscurely greenish (reaction nearly negative); KOH—all parts negative.

Spore deposit white. Spores 9.4-11.3 x 4.7-5 (-5.6)μ (Coker measured them 7.4-10 x 3.8-4.5 [-4.8]μ), oblong to subellipsoid, hyaline with yellow granulose content or with numerous yellow oil drops, walls thin and smooth. Hymenium present on the sides and apex of the fruitbody. Basidia narrowly clavate, (55-) 70-95 x (5.6-) 7-8.5μ, 4-spored, rarely 2-spored. Cystidia none. Subhymenium interwoven of yellow hyphae 2.8-4μ diam. Tramal hyphae hyaline to yellowish, 5.5-8.5μ diam., longitudinally parallel under the hymenium, interwoven in the center of the fruitbody. Clamp connections present.

In clusters under hemlock, Sept.

Material studied: CONNECTICUT: Redding, Sept. 6, 1919, Coker R. 27 (Type) (NCU).

Observations: The above macroscopic description was adapted from Coker's field notes included with the collection. The type collection is ample but in poor condition. The hyphae are so collapsed that accurate measurements are difficult to obtain and the collection has been severely attacked by another fungus at some time or other during its storage. The fruitbodies are now covered with innumerable alien spores but, fortunately, the spore deposit is clean. We attribute the weak $FeSO_4$ reaction to the fact that the collection appears to have been dipped in some chemical solution which may have interfered with the reaction. However, Coker's excellent notes, the good spore deposit, Miss Eaton's fine illustration (Coker 1932, Pl. 23), plus the collection, poor though it is, combine to provide a good concept of this taxon.

C. cokeri is very close to *C. subfastigiatus* but can be distinguished by its different colors and narrower spores. Both species occur in clusters in coniferous woods and both appear to be rare. The geographical range for neither is known at this time.

5. *Clavariadelphus unicolor* (Rav. ex Berk.) Corner, Ann. Bot. Mem. 1:284-285. 1950.

Craterellus unicolor Ravenel ex Berkeley, Grevillea 1:148. 1873.
Craterellus corrugis Peck, Bull. Torrey Bot. Club 26:69. 1899.
Clavaria pistillaris var. *unicolor* f. *A,* Coker, Jour. Elisha Mitchell Sci. Soc. 63:60. 1947.
Clavaria unicolor (Rav. ex Berk.) Doty, Ore. Monogr. Bot. 7:23. 1944.

Fruitbody 2.5-6 (-8) cm tall, 2-4 (-5) cm diam. at the apex, simple, clavate to obclavate with a rather short, equal to tapering base (5-8 mm diam.), soon flaring upward rather abruptly to become turbinate with a truncated apex which is frequently margined with an elevated, furrowed ridge, apex sometimes collapsing with age to form a cavity; pale ochraceous with tints of flesh pink, violet or red-brown ("tawny" to "ochraceous-tawny"), becoming darker and somewhat rufescent on drying ("brownish-vinaceous," "Rood's brown" to "Natal brown"), paler toward the base and over the apex; smooth becoming longitudinally rugose or nearly cerebriform near the margin of the truncation; context white, firm becoming floccose, odor and taste not recorded.

Chemical reactions: Dried material: $FeSO_4$—all parts green; KOH—all parts negative.

Spore deposit white. Spores (8-) 9.4-11 (-13) x (4.2-) 4.5-5.5 (-6)μ, ellipsoid to subovate, hyaline with yellow oil drops or granular content, walls thin and smooth. Hymenium present on the sides and sometimes over the apex of the fruitbody. Basidia narrowly clavate, (60-) 70-95 x 8.5-11μ with sterigmata up to 9.5μ long, mostly 4-spored but 2-spored ones also frequently present. Cystidia none. Subhymenium interwoven of hyaline to yellowish hyphae 2-4μ diam. The truncate apex fertile or sterile: If fertile, the hymenium continued from the sides but the subhymenium not differentiated over the apex. If sterile, the epicutis of the truncation of two general types with intermediate forms: 1. A hymeniform layer of yellow, tubular to narrowly clavate terminal cells 37-75 x 3-7 (-9.5)μ (Fig. 7); or 2. An interwoven layer of yellow, filamentous, flexuous, branched, terminal hyphae with cells 18-40 (-75) x 3-6 (-7.5)μ (Fig. 8), sometimes arising from a vertically oriented subcutis. Tramal hyphae hyaline to yellowish, 3.5-12 (-17)μ diam.; walls smooth to obscurely roughened, thin to slightly thickened; hyphae longitudinally parallel in the base and adjacent to the hymenium, interwoven in the center of the fruitbody; oleiferous hyphae frequently present. Clamp connections present.

Gregarious in predominantly deciduous woods, usually in southeastern United States, Nov.-Dec.

Material studied: TENNESSEE: Timberlake Road, Hesler 22240 (TENN); New Hopewell, Hesler 10091 (TENN), Hesler & A. J. S[harp] 7094 (TENN); Clinton Pike, Hesler 6544 (TENN); Ball Camp Pike, Hesler 1729 (TENN). NORTH CAROLINA: Chapel Hill, Reasoner 1994 (NCU), Couch 3885 (NCU), Coker & C. R. Bell 14062, 14064 (NCU).

Observations: The distribution of *C. unicolor* is interesting. Of all the herbarium material we examined the only collections we saw of it were from Tennessee and North Carolina. The original collection came from South Carolina, Murrill (1940) reported it from Florida, and Coker (1947) added Georgia to the list. Since there is so much evidence that *C. unicolor* is a southeastern United States species, it is surprising that it occured even once as far north as Massachussets–Peck's *Craterellus corrugis* (1899). We have not seen Peck's type collection but from his description and because *Clavariadelphus unicolor* is such a distinctive species, even in the dried condition, we feel that Burt (1914) was correct in placing *C. corrugis* in synonomy with *C. unicolor* Rav. ex Berk.

Doty's (1944) report of *C. unicolor* from the Pacific Coast is erroneous. The species he described is included in this paper as *C. mucronatus* and while there is some superficial resemblance, *C. unicolor* is readily distinguished by its broader spores, different structure over the apex, and its habitat in deciduous woods.

As far as we now know, *C. unicolor* is the only truncated species in *Clavariadelphus* in which the truncation can be either completely sterile or completely fertile. We have not studied sufficient material to report conclusively on the overall percentage of fertility vs. sterility, but in one relatively large collection we found it to be about 50-50.

6. *Clavariadelphus lovejoyae* Wells & Kempton, nom. nov.

Clavaria truncata Lovejoy, Bot. Gaz. 50:385. 1910.

Following is Lovejoy's original description:

"Pileate tops bright red, shading into reddish orange at top of stipe to dull flesh color at its base: ends truncate, convex to plane to somewhat concave, 0.5-3 cm. broad, smooth: whole plant to within a few centimeters of base of stipe covered with a white bloom, persisting in dried specimens: flesh creamy, spongy: stipe longitudinally grooved to base, 3-10 cm. long: spores white, 14 x 7μ.

"Habitat: Humus soil under balsam and spruce trees; gregarious and cespitose, 4-6 in a group; Foxpark, alt. 2900 meters, August 8, 1909, no. 66."

The following description is from our examination of the type collection:

Collection good, composed of 8-10 fruitbodies and a generous amount of substratum including white to tannish mycelium. No spore deposit. Dried fruitbodies up to 10 cm tall, up to 15 mm diam. at the apex, subclavate to truncate, base usually inflated; apex dull red to vinaceous red-brown, sides splotched with vinaceous red-brown near the apex, buff to grayish-brown below, base pallid tan (a few specimens have small, bright red spots just below the apex which look like lacquer or nail polish). The white bloom mentioned by Lovejoy is not now particularly discernable.

Chemical reactions: Dried material: $FeSO_4$–context dull green; KOH–hymenium discolors solution to pink.

Spores of two general sizes and shapes: 1. Mostly (9.4-) 10.7-13 (-13.8) x 5-6μ, broadly ellipsoid to oblong (Fig. 9); 2. Rather frequently 15-17 x (5.3-)

6-7μ, ellipsoid but compressed at the waist making them appear "peanut" shaped; both types hyaline with yellow oil drops or granulose content, walls thin and smooth (Fig. 9). Hymenium present only on the sides of the fruitbody. Basidia narrowly clavate, (54-) 75-94 x (7.7-) 10-12.3μ, mostly 4-spored but 2-spored ones also present. Cystidia none. Subhymenium interwoven of hyaline to yellowish hyphae 1.5-3μ diam. Truncation sterile or with scattered basidia near the margin; epicutis a hymeniform layer of yellowish cells of varied shapes: mostly tubular and occasionally apically branched, 30-61.5 x 3-6 (-7.5)μ; but may also be clavate to subventricose with rounded or subacute apices, 37-52 x 3.7-7.5μ (Fig. 10). Tramal hyphae hyaline to yellowish, smooth, 3-15μ diam. longitudinally parallel in the base and under the hymenium, interwoven in the center of the fruitbody. Clamp connections present.

Material studied: WYOMING: Foxpark, Lovejoy 66, (Type) (RM).

Observations: Most authors have placed Lovejoy's fungus in synonymy with *Clavariadelphus truncatus* (Quél.) Donk, but we consider it quite separate from that species because of its white spore deposit and the reddish fruitbodies which are still distinctively colored in the dried state. Lovejoy, herself, was aware of Fries' *Craterellus pistillaris* which is now widely accepted as a synonym of *Clavariadelphus truncatus,* but she maintained that in her collection of twenty specimens found in entirely different localities, not one had the coloring of that species.

The fact that the spores are of two sizes in *C. lovejoyae* is a deviation from other species we have studied in this genus. We note that Doty (1944) also observed this phenomenon when he examined the type collection. It will require a study of additional collections to determine whether or not this duo-spore size is a constant caracter for *C. lovejoyae.*

Presently, we consider *C. lovejoyae* to be most closely related to *C. borealis* but distinct from it by the reddish colored fruitbodies and the larger spores.

7. *Clavariadelphus borealis* Wells & Kempton, sp. nov. (Fig. 16).

Fructificatio 4.5-14 cm alta, 1.5-5 cm diam. ad apicem, simplex, subclavata mox turbinata; apex truncatus, sterilis, luteo-aurantiacus; latera laevia demum longitudinaliter rugulosa, obscure alutacea; basi pallens; contextus albidus, firmus demum floccosus, sapor dulcis vel amaro-dulcis similis *saccharine.* Sporae in cumulo albae, 9-11.3 x 4.7-6.6μ, late ellipticae. Cystidia nulla. Fibulae praesentes. Dispersa, gregaria, vel raro subcespitosa in sylvis coniferae. TYPUS: Wells et Kempton 8/24/66-10, Fairbanks, Alaska (W/K).

Fruitbody 4.5-14 cm tall, 1.5-5 cm diam. at the apex, simple, obtusely cylindrical to subclavate, broadening above to become turbinate with age, apex rounded at first but soon truncate, usually with an obtuse, puckered ridge around the margin of the truncation, disc sometimes perforated; primordia pallid, very soon yellowish over the apex, finally yellow-orange on the apex and dark alutaceous often with a tint of lilac on the sides, paler toward the base; moist to dry, unpolished, smooth becoming longitudinally rugose near the apex, base white mycelioid and with a fine network of white rhizomorphs; context white, unchanging or only faintly pinkish to brownish when cut or bruised, firmly stuffed becoming floccose in the upper part, odor none, taste sweet to sweetly bitter as of saccharine.

Chemical reactions: Fresh material: $FeSO_4$—all parts pale green; KOH—surface of apex and sides vivid pink to red, base and context negative; NH_4OH—same as KOH; phenol—all parts negative. Dried material: $FeSO_4$—all parts green; KOH—hymenium and surface of truncation pinkish red, context negative.

Spore deposit white. Spores 9-11.3 x 4.7-6.6μ, ellipsoid, hyaline with yellow oil drops or granulose content, walls thin and smooth (Fig. 11). Hymenium present only on the sides of the fruitbody. Basidia narrowly clavate, 82-105 (-116) x 9-11 (-13)μ, with sterigmata up to 10.7μ long, mostly 4-spored but some 2-spored ones usually also present. Cystidia none. Subhymenium interwoven of hyaline to yellowish hyphae 1.5-3.5 (4.6)μ diam. Truncation sterile or with scattered basidia near the margins; epicutis of two general types with intermediate forms: 1. A hymeniform layer of yellow to subhyaline, tubular to clavate cells 22-48 x 4-22μ, or of fusoid-ventricose cells 41-86 x 11-18μ (Fig. 12); and 2. an interwoven layer of yellow, filamentous, flexuous hyphae 1.8-4.6μ diam. Tramal hyphae hyaline to yellowish, 2.8-12 (-16)μ diam, walls smooth to obscurely roughened, thin to slightly thickened, longitudinally parallel in the base

Fig. 16. *Clavariadelphus borealis,* x 1. (W/K 8/20/67-20)

and under the hymenium, interwoven in the center of the fruitbody; oleiferous hyphae sometimes present. Clamp connections present.

Scattered, gregarious, or rarely subcespitose in mixed, but predominantly coniferous, woods, Aug.-Oct.

Material studied: (All collections are in W/K and were collected by Wells and Kempton unless otherwise stated.) ALASKA: Near Anchorage, 8/28/59-3, 8/24/64-4, 8/16/65-2, 9/13/65-9, 9/20/65-7, 8/15/66-13, 8/29/66-14, 8/29/66-15, 8/20/67-20, 9/6/67-6, 9/26/67-7. Near Fairbanks, 8/17/64-2, 8/24/65-9, 8/26/65-16, 8/24/66-10 (Type). Chitina, 9/4/66-5. Haines, 9/9/67-25. OREGON: Mt. Hood area: Still Creek, E. Wiebe 9/24/66-1, 10/7/66-1, 10/7/66-2; Hood River Meadows, 10/11/66-1.

Observations: The range of *C. borealis* in North America is not known at the present time. A few collections of it were found in Oregon during the season of 1966, and although it is not actually common in Alaska, it can be found every year in the south-central and interior regions. Because of the strong similarity of this species to *C. truncatus* it is likely that collections without spore deposits have been placed in herbaria under that name.

Section LIGULA Wells & Kempton, sect. nov.

Sporae anguste ellipticae, 3-5plo longiora quam latiora. TYPUS: *Clavariadelphus ligula* (Fr.) Donk.

KEY TO THE SPECIES

1. Apices of fruitbodies sterile, truncate and the truncation usually with a small, acute, central mucro; whitish at first, remaining pallid over the truncation with the sides becoming alutaceous to brownish-flesh . . . 8. *C. mucronatus*
1. Apices of fruitbodies fertile, rounded to rugose, variously inflated or laterally flattened to ligulate; fruitbodies yellowish at first becoming buff to alutaceous, apices more-or-less concolorous or with tints of yellow or green 2
   2. Spore deposit white; spores (10-) 12-15 (-18)μ long . . . . . 9. *C. ligula*
   2. Spore deposit ochraceous; spores (15-) 16-24 (-28)μ long . . . . 10. *C. sachalinensis*

8. *Clavariadelphus mucronatus* Wells & Kempton, sp. nov.

Fructificatio (2-) 3-6 (-8) cm alta, (5-) 10-15 (-25) mm diam. ad apicem, simplex, anguste clavata demum anguste turbinata; apex acutus autem mox truncatus, sterilis, plerumque mucronatus, mucrone parvo, acuto, centrali; alba, immutabilis ad apicem, latera fulvescens vel ex brunneo incarnata, laevia demum longitudinaliter rugulosa; contextus albidus, firmus demum floccosus, sapor indistinctus. Sporae in cumulo albae, (10.5-) 11-15 (-16.5) × 3.5-4.7μ, anguste ellipticae. Cystidia nulla. Fibulae praesentes. Gregaria in colonis in sylvis coniferae. TYPUS: Wells et Kempton 9/9/67-2, mile 40, Haines cut-off road, Alaska (W/K).

Fruitbody (2-) 3-6 (-8) cm tall, (5-) 10-15 (-25) mm diam. at the apex, simple, narrowly clavate and acute at the apex at first but soon truncate with the truncation plane to shallowly depressed and typically with a small, acute, central mucro, disc sometimes perforated with age; white or nearly white at first, remaining white or pale colored over the truncation with the sides becoming tan

to light brownish-flesh (sides "pale pinkish-buff" becoming "cinnamon-buff" to "vinaceous-buff"), base more or less concolorous; surface smooth becoming longitudinally rugulose on the sides, unpolished, base with scattered white strigosity and with scanty white mycelial mold throughout the substratum; context white, unchanging when cut or bruised, firm becoming floccose, sometimes hollowed in the upper part, odor and taste not distinctive or slightly bitter to metallic.

Chemical reactions: Fresh material: $FeSO_4$—all parts greenish; KOH—all parts negative; phenol—hymenium brownish, context negative. Dried material: $FeSO_4$—all parts green; KOH—all parts negative.

Spore deposit white. Spores (10.5-) 11-15 (16.5) x 3.5-4.7μ, narrowly ellipsoid, straight or the longer ones slightly "sway-backed" in profile, hyaline with yellow oil drops or granulose content, walls thin and smooth (Fig. 13). Hymenium present only on the sides of the fruitbody. Basidia narrowly clavate, 49-75 x 5.3-7.5μ, with sterigmata up to 7.5μ long if 4-spored, up to 9.5μ on some 2-spored basidia. Cystidia none. Subhymenium interwoven of hyaline to yellowish hyphae 1.5-3.5μ diam. Truncation sterile; epicutis a thin layer of yellowish, interwoven, filamentous hyphae 2-3.7μ diam. which become appressed and very cohesive with age. Tramal hyphae hyaline to yellowish, (2.5-) 3-11.3μ diam., walls smooth to obscurely roughened, thin to slightly thickened; hyphae longitudinally parallel in the base and adjacent the hymenium, interwoven in the center of the fruitbody. Clamp connections present.

Gregarious in colonies on coniferous debris, Sept.-Nov.

Material studied: ALASKA: Mile 40, Haines cut-off road, Wells & Kempton 9/9/67-2 (Type), 9/9/67-3 (W/K). OREGON: Still Creek, Mt. Hood Nat. Forest, Smith 28485 (MICH). WASHINGTON: Spanaway Park, Mt. Rainier Nat. Park, Bigelow 49509 (MICH); Klikitat Co., woods above Trout Lake, Wm. B. Cooke 9618, 9620 (CINC); Gov't. Mineral Springs, Thos. McGinnis 11/5/67-1 (W/K).

Observations: This species is closely related to *C. ligula.* According to Doty (1944), who confused it with *C. unicolor,* it may occur at the same time and in the same vicinity as *C. ligula.* Although we were unable to obtain Doty's collections for study, his description and comments are so decidedly in line with our concept of *C. mucronatus* that we do not hesitate to refer the fungus he described in his work to this species.

C. mucronatus is readily distinguishable from *C. ligula* by its sterile, truncate-mucronate apex and paler colors, and from *C. unicolor* by its narrower spores, coniferous habitat, truncate-mucronate apex, different colors and generally smaller size. It is true that in dried material large fruitbodies of *C. mucronatus* may bear some superficial resemblance to small fruitbodies of *C. unicolor,* but their microscopic characters are entirely different.

In habit and habitat, *C. mucronatus* is like both *C. ligula* and *C. sachalinensis* in that it grows densely gregarious on debris of a variety of coniferous trees. Doty, (1944, as *Clavaria unicolor*) reports it on needle debris of *Picea engelmanii* and *Pseudotsuga taxifolia.* Our Alaskan collections were on debris under *Tsuga heterophylla* with *C. sachalinensis* in the vicinity. Although *C. mucronatus* is usually found in large numbers, it may be rare, and possibly also confined to the northwestern part of North America.

The Bigelow collection cited above (*49509,* MICH) was covered with conidiospores from a species determined by Dr. Clark T. Rogerson of the N. Y. Botanical Garden as (personal communication) "a species of *Penicillium* belonging to the *Asymmetrica* section. . .probably secondary, not a parasite." Doty (1944) noted that the two W. Bridge Cooke collections from Washington were immature. Although we were able to do a sufficient amount of microscopic work on these collections, they are in rather poor condition, possibly the result of having been dried in a plant press.

9. *Clavariadelphus ligula* (Fr.) Donk, Rev. Niederl. Homobas. Aphyll. 2:73. 1933.

Clavaria ligula Fr., Syst. Mycol. 1:477-478. 1821.

Fruitbody 2-5.5 (-7) cm tall, 3-12 (-25) mm diam. at the apex, simple, cylindrical to clavate often becoming irregularly flattened or subspathulate to ligulate with age, apex subacute to obtuse becoming rugose to irregularly inflated; "pale ochraceous-buff" to "pale salmon" or "vinaceous-buff," apex concolorous to slightly darker, typically unicolorous and near "chamois" when dried; smooth becoming rugulose, base white tomentose to strigose with abundant white mycelium binding the substratum; context white, unstaining, firm becoming floccose in the apex, odor none, taste none to slightly bitter or metallic.

Chemical reactions: Dried material: $FeSO_4$—all parts green; KOH—all parts negative.

Spore deposit white. Spores (10-) 12-15 (-18) x (2.8-) 3-4.5 (-5)μ, narrowly ellipsoid, straight or the longer ones slightly "sway-backed" in profile, hyaline with yellow oil drops or granulose content, walls thin and smooth (Fig. 14). Hymenium present on sides and apex of the fruitbody. Basidia narrowly clavate, (40-) 50-75 (-86) x 6.5-9.5μ with sterigmata up to 9μ long, mostly 4-spored but 2-spored ones also frequently present. Cystidia none. Subhymenium interwoven of hyaline to yellowish hyphae 2-3.5μ diam. Tramal hyphae hyaline to yellowish, 3-9.5μ diam., walls smooth to obscurely roughened, thin to slightly thickened; hyphae longitudinally parallel in the base and adjacent to the hymenium, interwoven in the center of the fruitbody. Clamp connections present.

Gregarious to subcespitose in colonies on coniferous debris, July-Oct. (-Nov.).

Material studied: United States: CALIFORNIA: Sumner, Lanphere 10460 (MICH). IDAHO: Priest Lake, R. H. Petersen C1866, C1877, C1896, C1960 (RHP), Smith 71055 (MICH); Payette Lakes, Smith 45132 (MICH), Bigelow 46882 (MICH). MAINE: Guerette, Bigelow 3706 (MICH); Madawaska Lake, Bigelow 3485 (MICH). MICHIGAN: Tahquamenon Falls, Leathers 101, 444 (MICH); Carson City, V. P[otter] 10250, 10260 (MICH). OREGON: Mt. Hood, Bear Springs, Ore. Mycol. Soc. 49495 (MICH). PENNSYLVANIA: Buck Hill Falls, Delafield Sept. 20, 1919 (NCU). WASHINGTON: Stevens Co., Cooke 22875, 22876, 22877 (DAOM); Longmire, Smith 49370 (MICH). Canada: MANITOBA: Victoria Beach, Bisby F7132 (DAOM), Buller and Bisby F7133 (DAOM). NOVA SCOTIA: Kentville, Harrison 95816, 95902, 111220 (DAOM). ONTARIO: Bell's Corners, Elliott 54287 (DAOM); Bond Lake, Bell 7421 (TENN); Tilsonburg, Dearness 15256 (TENN); Lake Timagami, Smith 4864-A (MICH). QUEBEC: Stevenson 95815 (DAOM). Sweden: Uppland, Melderis 65949 (DAOM); Helsingland, Romell 72062 (DAOM). Switzerland: Favre Sept. 12, 1946 (MICH).

Observations: Corner (1950) states that *C. ligula* is little known. We believe that part of the problem stems from the fact that many authors have considered it to be merely a small version of *C. pistillaris.* It is, however, easily distinguished from *C. pistillaris* by its narrower spores, coniferous woods habitat, color, and lack of staining, as well as its generally smaller size.

The occurrence of *C. ligula* in North America may also have been confused by Coker (1923) who published an illustration of a pink *C. ligula* and described it as, "When fresh dull pink, soon fading to leather color or with tints of fawn or buff added." We admit that we have never seen *C. ligula* in fresh condition, but our examination of the Buck Hill Falls collection illustrated shows that any pink color which might have existed has disappeared with drying, or with age, as Coker indicated. Since the spores measure 12.3-16 x 3-4.6μ, this collection now agrees both macroscopically and microscopically with our concept of *C. ligula.*

Coker (1923) drew his microscopic data for *C. ligula* from a collection taken in the Adirondacks, New York (*Murrill 70,* NCU). He reported the spores were long, narrow, 15-18.5 x 4.5-5μ, and that there were no clamp connections present. Although this collection is now in poor condition with most of the hymenium gone, we were able to ascertain that clamp connections are present, and the few spores seen measured 16.9-20 x 4.6-6μ. The long spores indicate that Murrill's collection is probably *C. sachalinensis* rather than *C. ligula.*

We have not been able to distinguish *C. ligula* from *C. sachalinensis* in dried collections without a microscopic examination and we do not know whether they can be distinguished from one another in the field. However, no real problem exists in differentiating them. In *C. ligula,* the spore deposit is white and the spores are rarely over 15μ long; in *C. sachalinensis,* the spore deposit is ochraceous and the spores are usually well over 15μ long.

The range of *C. ligula* in North America is not known but all the collections we examined came from northern United States and southern Canada, which may indicate that it is limited to a rather narrow geographical zone. In addition, field notes included with collections always mentioned a coniferous habitat and most often, specifically mentioned pine. We doubt that *C. ligula* is restricted to pine debris, but the point is open for further study.

10. *Clavariadelphus sachalinensis* (Imai) Corner, Ann. Bot. Mem. 1:282. 1950. (Fig. 17).

    Clavaria sachalinensis Imai, Trans. Sapporo Nat. Hist. Soc. 11(2):73. 1930.

Fruitbody 2-7(-15) cm tall, 3-15 (-35) mm diam. at the apex, simple or occasionally briefly branched above, cylindrical to subclavate becoming clavate to subventricose, apex acute to obtuse becoming rugose to irregularly inflated, rarely perforated in extreme age; light yellow to buff becoming dull yellow to alutaceous, apex concolorous or yellow-green to olive-green; unpolished, smooth becoming rugulose, base strongly white pruinose to substrigose and with abundant white mycelium binding the substratum; context whitish, unstaining, firm becoming floccose in the upper part, odor none, taste none or slightly bitter.

Chemical reactions: Fresh material: $FeSO_4$—all parts green; KOH—all parts negative; phenol—all parts negative to obscurely brownish. Dried material: $FeSO_4$—all parts dark green; KOH—all parts negative.

Spore deposit ochraceous. Spores variable in length, (13-) 16-24 (-28) x 4-6μ, narrowly ellipsoid, straight in face view, usually curved and appearing "sway-backed" in profile, hyaline with yellow oil drops, walls thin and smooth (Fig. 15). Hymenium present on sides and apex of the fruitbody. Basidia narrowly clavate, (56-) 60-90 (-115) x (7.5-) 8.5-11 (-13)μ with sterigmata up to 9.2μ long, mostly 4-spored but 2-spored ones usually also present. Cystidia none. Subhymenium interwoven of hyaline to yellowish hyphae 2-4.5μ diam. Tramal hyphae hyaline to yellowish, 3.5-7.5 (-11)μ diam., walls smooth to obscurely roughened, thin to slightly thickened, longitudinally parallel in the base and under the hymenium, interwoven in the center of the fruitbody. Clamp connections present.

Gregarious to densely gregarious in colonies on debris of coniferous trees, July-Oct.

Material studied: United States: ALASKA: (All collections are in W/K and were collected by Wells and Kempton.) Anchorage, 8/4/60-1, 9/12/60-4, 8/16/65-1, 9/25/65-4, 8/18/66-3; 1600 ft. elev., 9/10/64-9, 9/16/65-13, 8/11/66-3; Bird Creek, 8/31/59-6, 8/6/64-2, 8/27/64-7, 8/18/65-8, 9/20/65-12, 8/11/66-20, 8/18/66-1, 8/18/66-7, 8/29/66-6, 9/11/66-1, 7/20/67-19, 8/2/67-10; Chitina, 9/4/66-6, 9/5/66-12; Fairbanks, 8/23/65-4, 8/23/65-5,

Fig. 17. *Clavariadelphus sachalinensis,* x 1. (W/K 8/16/65-1)

8/24/65-8, 8/24/65-12, 8/25/65-2, 8/26/65-1, 8/26/65-2, 8/26/65-3; Haines, 9/9/67-4, 9/10/67-24; Homer, 9/2/67-4; Hope, 9/22/66-9, 9/22/66-10; Ingram Creek, 9/20/65-11; Skilak Lake, 8/9/65-3, 7/25/65-4, 9/8/65-3, 9/8/65-4. COLORADO: Grand Lake, Paul & Virginia Shope 15612 (TENN), 53207 (DAOM). IDAHO: Payette Lakes, Smith 58371 (MICH); Priest River Exp. Forest, Smith 70821 (MICH); Upper Priest River, Smith 71489, 74177 (MICH); McCall, Smith 59172, 59785 (MICH); Nordman, Smith 54567 (MICH). MAINE: Guerette, Bigelow 3071, 3271, 3447, 3606 (MICH); Smith 3596 (MICH). MICHIGAN: Wilderness State Park, Thiers 3228 (MICH), Smith 63355 (MICH). NEW MEXICO: Mountains near Santa Fe, Barrows 234, 440, 487 (MICH). OREGON: Mt. Hood area, H. V. Smith & R. Keene 10/8/66-1 (W/K), Petersen 10/8/66-2 (W/K), Wiebe 11/5/66-1 (W/K), Phelps 11/6/66-1 (W/K), Ore. Myc. Soc. 10/10/66-2, 10/10/66-3, 10/10/66-4 (W/K). Canada: BRITISH COLUMBIA: Prince George, Ziller 21598 (DAOM); Crescent Spur, Engelhardt 30839 (DAOM); Silverton, Pole Blight Reserve, Ziller 35242 (DAOM). QUEBEC: St. Aubert, Groves & Jackson 16807 (DAOM); Baie St. Paul, Elliott & Kendrick 53550 (DAOM).

Observations: Corner (1950) correctly suspected that *C. sachalinensis* occurred in North America. In fact, we have found it to be widespread on this continent and extremely common in Alaska. It is also rather variable but we have not been able to correlate differing features such as size, color, taste, spore length, etc. into any pattern dependable enough to divide the species into varieties or forms.

In addition to the taxonomic characters given for this species, we found a curious feature which is so constant that it almost has taxonomic value—a paucity of either mature or immature spores in mounts of sectioned material. It has often been necessary to examine several fruitbodies from a single collection before any spores could be found. This condition was occasionally evident in sectioned material of *C. ligula,* but never to the degree exhibited by *C. sachalinensis.*

Since *C. sachalinensis* is so common in Alaska, we undertook a simple field project which we hoped would shed some light on the sporulation pattern and the longevity of the fruitbodies. On August 11, 1966, we took a collection of variously sized fruitbodies from the first colony to appear and tagged about 30 of the remaining 100-150 fruitbodies. Thereafter, we took collections every 7-10 days and compared tagged specimens from this colony with others in the vicinity. The fruitbodies were examined while fresh before a deposit was attempted, examined again in the fresh condition after a deposit was obtained, and a final examination of the same material was made after it had been dried. On September 11, 1966, we took the last collections when signs of a light frost were evident. The results were as follows:

1. Mature and immature spores were rare to absent in all examinations of sectioned material.
2. Heavy spore deposits were obtained from all but the very smallest fruitbodies in the first sampling.
3. We found no correlation between the age of the fruitbody and the size and shape of the spores:
   1st week—20.6-28 x 4.2-5.6μ
   2nd week—17.8-24.4 x 4.7-6μ
   3rd week—23.4-28 x 4.7-5.6μ
   4th week—20.6-26 x 3.7-5.6μ
4. There was no correlation between basidial size and spore size; i. e. fruitbodies with large basidia did not necessarily produce large spores.

5. The hymenium did not thicken appreciably in depth with age.
6. Old fruitbodies frequently became spotted with brown, or browned from the tips downward after a light frost.
7. None of the specimens were invaded by larvae or attacked by fungal parasites though both were present on other fungi in the vicinity.

Although this study shed little light on the problem of why there is such a dearth of spores in mounted sections of *C. sachalinensis*, we do know that this species can produce spores constantly over a period of at least thirty days.

EXCLUDED SPECIES AND VARIETIES

Clavariadelphus fistulosus (Fr.) Corner. We have not seen authentic material of this species.

Clavariadelphus junceus (Fr.) Corner. We have not seen sufficient material.

Clavariadelphus maricolus (Kauff.) Corner. According to Dr. A. H. Smith (personal communication), the type collection is unsatisfactory for study.

Clavariadelphus pistillaris (Fr.) Donk var. *americanus* Corner. This variety was based on literature and we have seen no specimens which could be referred to it.

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ODD AND UNUSUAL DISCOMYCETES FROM MICHIGAN, I

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Among Michigan's more unusual cup-fungi, *Peziza proteana* (Boud.) Seaver is noteworthy because of the variability of the ascocarps in their general appearance. Two forms of this species are recognized: f. *proteana* in which the ascocarps have the typical cup-shaped appearance, and f. *sparassoides* (Boud.) Korf (Mycologia 48: 714. 1956). In the later the individual ascocarps are typically fused at their bases and are one-sided to spathulate; this gives the cluster the appearance of a *Sparassis*-type fruit-body. The unusual morphology is mirrored in its common name of "cabbage-head fungus." For many years the relationship between the two forms was not understood and the sparassoid form was placed with the Tubers and the Helvellas.

According to Dr. Korf, the sparassoid form is considered to be an excellent edible fungus by a number of collectors. Although this species has been found in Michigan on several occasions and is known from many parts of the United States and Europe, it is considered a rare fungus. On October 6, 1967, Florence Hoseney found an excellent fruiting of this fungus containing both forms. This fruiting occured where a diseased elm had been removed and the stump burned at the University of Michigan Botanical Gardens. The following is a description of Mrs. Hoseney's collection.

Macroscopic features: f. *proteana.*

Apothecia densely gregarious on burnt ground, reaching 9 cm in diameter, 5 cm in depth, regularly cup-shaped, split on one side or sometimes petaloid; hymenium often radially wrinkled from the area of attachment of the apothecium, pallid to light brown or often lilac tinted; outer surface of the ascocarp concolorous with the hymenium or slightly darker except paler near the base, appearing mealy in older specimens; margin often splitting in age, often darker in color than the hymenium; consistency very fragile.

Macroscopic features: f. *sparassoides* (Fig. 1).

Clumps up to 20 cm in diameter; apothecia commonly split down one side, fused at or near the base. Similar to the above in other respects.

Microscopic characters (the same for both forms):

Spores hyaline, unicellular, 2-guttulate, nearly oblong, often with apical truncate projections, remainder of ornamentation composed of irregular ridges and warts, staining fairly readily in cotton blue, 10.5-12 x 4.5-6μ.

Asci 8-spored, cylindric, operculate, 182-230 x 7.8-10μ; wall, especially around the operculum, blue in Melzer's reagent; paraphyses septate, 3-4μ at the base, 4-7μ wide at the apex, narrowly clavate.

Outer layer of the apothecium composed of large more or less globose cells and with some interwoven hyphae; middle layer of interwoven hyphae and interior to this a layer of inflated cells, the latter merging into the hymenium.

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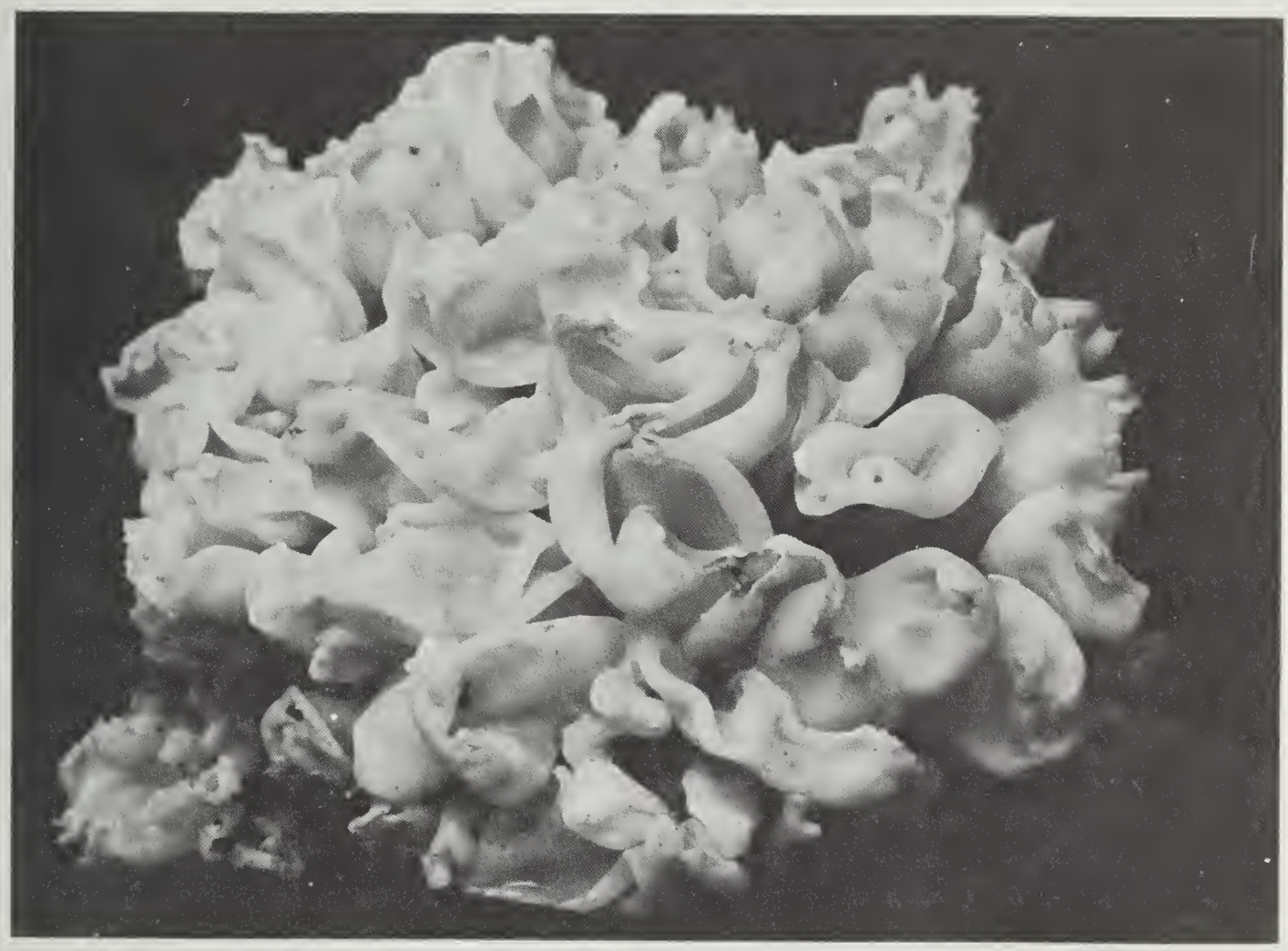

Fig. 1. *Peziza proteana* f. *sparassoides,* x½. (Photo A. H. Smith)

ASEXUAL REPRODUCTION IN THE BURNING BUSH, *EUONYMUS ATROPURPUREUS*

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The burning bush, *Euonymus atropurpureus* Jacquin (Celastraceae) is a shrub or small tree found in various habitats throughout its range from Ontario to Montana south to eastern Virginia, Alabama, and Tennessee (Fernald, 1950).

Fig. 1. Rhizome and aerial stems of *Euonymus atropurpurens* (Musselman 1611) in winter condition, from Laona Township, Winnebago Co., Illinois (T29N, R11E). Arrow indicates level of soil surface. Note heavy browse by rabbits on stem at extreme right.

In southern Wisconsin and northern Illinois, it is most commonly found along streams (Fell, 1955; Hartley, 1966). According to Curtis (1959), in Wisconsin it reaches its highest frequency value in the southern wet forest community. I have collected it in the Illinois-Wisconsin state line area in mesic woods, on a dry exposed roadside (Musselman 1613), and in river bottom forests. Specimens are deposited in the herbarium of the University of Wisconsin Rock County Campus, Janesville, Wisconsin.

The genus *Euonymus* contains many species which reproduce asexually from the stem. Bailey (1942) lists *Euonymus obovatus, E. nanus, E. patens,* and *E. radicans* as rooting from the stem or spreading by runners. Braun (1961) records the commonly planted European species *Euonymus europaeus* as escaping and reproducing by runners from the stem. However, neither Bailey nor Braun record any form of asexual reproduction for *E. atropurpureus.* McNair (1930) failed to mention any form of asexual reproduction in *E. atropurpureus* in an anatomical investigation of several species of *Euonymus.*

I have observed vigorous asexual reproduction by well developed rhizomes in every stand of *E. atropurpureus* I have studied. The rhizomes arise 1 to 15 centimeters below the soil surface and grow horizontally producing numerous small roots and occasional aerial stems. The rhizomes are white with a soft cortex that is easily peeled from the hard woody stele. The rhizomes may be up to three centimeters in width and produce numerous buds in addition to the roots and aerial stems.

Excavations in stands of *E. atropurpureus* in the Illinois-Wisconsin state line area reveal a complex intertwining network of rhizomes suggesting that it is possible that one stand could be a clone consisting of a single genotype arising from a single seed. Such stands contain stems that are tallest and oldest in the center with shorter, younger stems at the periphery indicating that the plants in the center may have given rise to surrounding stems by rhizomes.

ACKNOWLEDGMENT

I wish to thank Mr. Steven Houge for photographic assistance.

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SEASONAL CHANGE IN A SAND PRAIRIE IN VAN BUREN COUNTY, MICHIGAN

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Seasonal change was one of the first aspects of community organization to be recognized and described, but few phenological reports have been published. The information presented here is the result of a study of aspection on a sand area dominated by prairie plants. The study took place in the spring, summer, and fall of 1966.

STUDY AREA

The study area lies about two miles southwest of Mattawan, Van Buren County, Michigan, in the SE ¼ of Sect. 22, R 13 W, T 3 S. It consists of a narrow strip lying southeast of the New York Central Railroad, between Drape Ave. and West Robinson Ave. A seldom-used wheel-track runs through the southwestern half of the area. Total length of the area is about 4,000 feet and the width is about 150 feet. Elevation is mostly 820-840 feet above mean sea level. Part of the area is sand that may have been exposed in construction of the embankment on which the railroad is located; another part may have been an old railroad bed. No major disturbance to the area sampled has taken place during the three-year period in which the area has been intensively studied. Local residents cannot remember any major fire or disturbance in the area for at least six years.

METHODS

In June of 1965, sixteen four square meter plots were placed randomly throughout the study area. Each plot was divided into 16 1 square meter quadrats, thus making a total of 256 1 square meter quadrats. All vascular plants rooted in the quadrats were noted so that frequencies could be determined.

The area was visited once a week in the early part of the study (starting March 1, 1966) and at least twice a week during the middle and later part of the study (May to Nov., 1966).

Following Ahshapanek's method (1962), I departed from the traditional method of dividing the year into four rigid three-month seasons. Instead, my seasons were based on phenological data, especially that of the time of flowering. Thus the seasons and dates are not static, but change from year to year depending on the environmental conditions present. In 1966 I defined them as follows: hiemal, Nov. 20-May 3; vernal, May 3-June 7; aestival, June 7-Aug. 25; and autumnal, Aug. 25-Nov. 20.

Three phenological stages were used in this study. They were flowering, first appearance of fruit, and time of distribution of seed. At the time of flowering the heights of the plants were measured.

Of the sixty-one species so far found on the study area, the twenty-four species with the highest frequencies were given formal consideration.

COMPOSITION OF VEGETATION

Five species, *Andropogon scoparius, Helianthus occidentalis, Poa compressa, Rosa carolina,* and *Panicum oligosanthes,* were found to have a frequency of 50 per cent or higher. Three species had frequencies between 40% and 50%. They were *Rumex acetosella, Tradescantia ohiensis,* and *Panicum perlongum.* The other species in Table I had frequencies of 4.2 to 39%.

Application of Raunkiaer's life form system indicated that the area was dominated by hemicryptophytes (77%), followed by therophytes (11.4%), geophytes (5.7%), and nanophanerophytes (5.7%). This classification is based on Ennis's list of life forms (1928).

WEATHER

Temperature and precipitation data were determined from daily records of the U.S. Weather Bureau Station at Kalamazoo State Hospital, published in Climatological Summaries for Michigan, 1966. This weather station is about fourteen miles from the study area and thus only approximates the conditions there.

Precipitation in 1966 was about three inches above the long-term average of approximately thirty-five inches and 1965 was about equally wet. January, February, June, July, and September were months of below-average precipitation; March, April, May, and August, months of above-average precipitation. Temperatures showed no major departures from normal. In 1966, the last spring frost was May 10 (average, May 4) and the first autumn frost Oct. 6 (average, Oct. 14).

SEASONAL CHANGE

The 24 most frequent species, their times of flowering, their average heights during flowering, their times of fruiting, and their dates of seed dispersal can be found in Table I.

The hiemal season ran from Nov. 20 to May 3. During this time most of the activity of growth had ceased. The dried stems of *Andropogon scoparius* and *Andropogon gerardi* were still standing in early November. In fact they were sometimes present in the next summer's growth. An occasional green rosette of pussy-toes or some goldenrod could be seen. Frost tended to hasten the deterioration of vegetation. As Weaver (1958) discovered in the Iowa prairie, the living population of this prairie was in a dormant state and was found almost entirely within the protecting soil.

The vernal season ran from May 3 to June 7. None of the 24 species of plants was found in flower in the early part of May and the prairie retained its characteristic hiemal appearance except for a few green leaves of bluestem (*Andropogon scoparius* and *Andropogon gerardi*), *Poa compressa, Poa pratensis, Fragaria virginiana,* and *Phlox pilosa.* During the latter part of the month, two of the 24 species studied were in flower. They were *Rumex acetosella* and *Poa pratensis.*

Early June found four species of plants in flower. They were *Fragaria virginiana, Poa compressa, Rosa carolina,* and *Phlox pilosa. Fragaria virginiana* was one of the first species to bloom. Its white flowers could be seen sporadically

throughout the prairie. *Poa pratensis,* which flowered during the vernal season, and *Poa compressa* were now taller than all the other species. They tended to be quite conspicuous throughout the growing season. By late July *Poa pratensis* had turned brown and remained this way until early November. This was not true of *Poa compressa* which stayed green until October.

TABLE I. List in order of their appearing in flower, their date of flowering, height at time of flowering, and date of seed dispersal for species on a sand area in Van Buren County. Note: number in parentheses indicates number of plants used to determine avg. height.

Species	Date first found in flower	Avg. height of plant at time of flowering	Date of first seed formation	Date of first seed dispersal
Rumex acetosella	May 23	12.6 cm (10)	June 4	July 1
Poa pratensis	May 23	27.2 cm (10)	June 17	July 1
Rosa carolina	June 4	21.5 cm (10)	July 17	———
Poa compressa	June 4	17.4 cm (10)	June 29	July 17
Fragaria virginiana	June 4	11.3 cm (10)	June 17	July 1
Phlox pilosa	June 4	22.0 cm (10)	June 29	July 15
Tradescantia ohiensis	June 10	37.8 cm (10)	July 1	July 17
Euphorbia corollata	June 17	19.4 cm (10)	July 17	July 21
Melilotus officinalis	June 17	71.1 cm (10)	June 29	July 1
Cyperus schweinitzii	June 17	27.5 cm (10)	July 15	July 17
Specularia perfoliata	June 27	28.3 cm (5)	July 1	July 1
Panicum perlongum	July 1	18.7 cm (10)	July 17	July 29
Panicum oligosanthes	June 29	32.1 cm (10)	July 15	Aug. 1
Erigeron strigosus	July 1	44.7 cm (10)	July 17	———
Hypericum perforatum	July 1	21.7 cm (10)	July 21	Aug. 14
Oenothera rhombipetala	July 15	32.5 cm (10)	Aug. 1	Aug. 14
Aster azureus	July 15	82.0 cm (5)	Aug. 3	———
Helianthus occidentalis	July 21	90.0 cm (5)	Aug. 14	———
Solidago speciosa	July 21	80.0 cm (10)	Aug. 14	———
Artemisia caudata	July 24	88.3 cm (5)	Aug. 1	———
Andropogon scoparius	Aug. 14	78.8 cm (5)	Aug. 14	———
Andropogon gerardi	Aug. 14	120.0 cm (10)	———	———
Rubus sp.	July 15	———	Aug. 3	Aug. 14
Pteridium aquilinum	———	———	———	———

The aestival season was by far the most active growing period on the area. It began about June 7 and ran till about August 25. It was during the aestival period that many of the characteristic prairie species were seen. The first conspicuous flower to be seen in the early part of this period was spiderwort (*Tradescantia ohiensis*). The next two species to appear in the prairie during the aestival season were *Euphorbia corollata* and *Specularia perfoliata. Euphorbia corollata* or flowering spurge stayed in flower throughout the aestival season, often bearing fruit and flowers simultaneously.

Toward the end of June and the beginning of July the introduced weed *Hypericum perforatum* began to bloom. The middle of July saw *Panicum oligosanthes* and *Aster azureus* in flower. With the addition of these species to the list, the community now had many of the characteristics of a relic prairie. In late July one *Solidago* and *Helianthus occidentalis* appeared in flower.

During August the last massive growing stage took place on the prairie with the full growth of *Andropogon scoparius* and *Andropogon gerardi.* These were two of the last species to flower and finished their life cycles in August.

The autumnal season from Aug. 25 to Nov. 20 saw the plants of the prairie reach the end of their growing season, disperse their seeds, and collapse to rest and wait for the next yearly cycle to begin. Plants that dispersed their seeds at this time were *Oenothera rhombipetala, Hypericum perforatum,* and *Panicum oligosanthes.*

STRATIFICATION

In any community there is a continual fight for survival among its species. The prairie is no exception, even though the observer may see an orderly sequence of events as he watches the prairie throughout the year. Even though there is this continual fight for survival on the prairie there is also an example of co-existence with a large number of plants making complementary use of the environment. In this area, as in prairie areas previously studied (Weaver and Fitzpatrick, 1934; Curtis, 1959; Brewer, 1965), the smaller plants flower in early spring and early summer before the larger plants flourish and take the majority of the sunlight and nutrients. This form of stratification would also be favorable to pollination both by wind and insects. It is interesting to note that those plants which deviate most from this trend are weeds and not prairie species (Table I).

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ANNOUNCEMENT

SOME COMMON MUSHROOMS OF MICHIGAN'S PARKS AND RECREATION AREAS

By Alexander H. Smith & Helen V. Smith

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THE DUCKWEEDS OF MINNESOTA

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University of Southwestern Louisiana, Lafayette

INTRODUCTION

The duckweeds (Lemnaceae) contribute an often considerable and conspicuous part of the aquatic vegetation of Minnesota, a state ("The Land of 10,000 Lakes") with about 4000 square miles of water area. Duckweeds occur throughout the state, sometimes in such incredible myriads as to suggest that numerically they are the most abundant of Minnesota's higher plants. Hicks (1937) estimated that "Compact floating mats of duckweeds. . .contain from 100,000 to 200,000 plants per square yard of water surface (genus *Spirodela*), 300,000 to 800,000 per square yard (genus *Lemna*), and 1,000,000 to 2,000,000 per square yard (genus *Wolffia*)." From these figures we estimate that, in a *Wolffia*-covered pond 50 feet wide which we saw near Baxter, Cass County, Minnesota, there were about 315,000,000 individual *Wolffia* plants, a figure about 1½ times the population of the United States.

The materials upon which our study is based are from two sources: (1) exsiccata from the herbaria of the University of Minnesota, Minneapolis (MIN) and Duluth (DUL), and the University of California, Berkeley (UC), totalling 244 sheets; and (2) our 127 Minnesota collections preserved in 50% methanol (LAF). In many of the herbarium specimens there was more than one species of duckweed per collection; a few included all five members of the Lemnaceae known from Minnesota. Most of our own collections contained more than one species. Our collections, from 41 of Minnesota's 87 counties, formed the basis for about 40% of the dots on our distribution maps (figs. 7, 8, 9, 10). A complete list of exsiccata and pickled specimens examined by us is available upon request.

During July and August 1967, while at the University of Minnesota Forestry and Biological Station at Lake Itasca,[2] we made, separately, several duckweed-collecting trips that totalled about 2700 miles and that took us through a considerable portion of the state. Some areas proved to be good collecting sites; others, especially the northwest and the northeast, were the source of relatively few specimens.

FLOWERING OF DUCKWEEDS

Although it has become axiomatically accepted by many authors that most Lemnaceae very rarely flower, some never, because of the family's phylogenetic loss of morphological complexity and their adeptness at vegetative reproduction, we feel that this "axiom" is questionable. About 8% of the collections examined by us contained fertile plants. Although this seems like a small percentage, it must be taken into account that these collections were made, in

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[2]During this time, HLC held a stipend for summer research under NSF grant GB3390.

respect to their fertility, randomly. Is it not possible that the flowers of most duckweed species are as seasonal and ephemeral as are those of many other angiosperms, as for example maples or oaks or buttercups or catalpas? Consider, if you will, what percentage of oak specimens, collected at random times of the year, would be in flower. We know of no one who would limit his collection of Lemnaceae to fertile plants only, as is usually the case with most other angiosperms. Duckweed flowers are, to say the least, not the most conspicuous and showy, but they *can* often be found with diligent searching—equivalent to that necessary to find the first trillium of the season as the winter snows have melted. Schleiden (1839) observed, for three consecutive years, the annual production of flowers of three species of *Lemna* in the vicinity of Berlin and concluded that (translation ours), "After my observations, I must maintain that these three species of *Lemna* flower at least as often as other phanerogams and that it is solely the collector at fault [". . .es nur Schuld der Suchenden ist. . ."] because flowers have been so seldom found."

It is also entirely possible that some species that have only rarely been found fertile, such as *Spirodela polyrhiza,* flower only in response to extreme environmental conditions rather than to photoperiodic and other seasonal changes. The excellent studies by Hillman (1959a, 1959b), Kandeler (1955, 1963, 1964, 1966), Landolt (1957), and others of the physiology and experimental control of flowering in *Lemna* are now leading to an understanding of these processes, not only in Lemnaceae but in other plants as well. By application of the results of these studies of plants in carefully controlled environments, perhaps more can be learned of the phenology, such as it may be, of duckweeds in their natural habitats in Minnesota.

SYSTEMATIC SECTION

The duckweed flora of Minnesota consists of five species in three genera: *Spirodela polyrhiza, Lemna minor, L. trisulca, Wolffia columbiana,* and *W. punctata.* Three additional species have been reported to occur in the state: *Lemna gibba* (Daubs, 1965), *L. obscura* (Daubs, 1965), and *L. perpusilla* (Gleason, 1952; Gleason & Cronquist, 1963; Lakela, 1965; Moore and Tryon, 1964; Moyle & Hotchkiss, 1945; Muenscher, 1944). We exclude these from the state's flora; they are discussed below under *L. minor.*

As an aid in the understanding of various terms used in the keys and descriptions, we have included, in place of a glossary and as fig. 6, a labelled diagrammatic drawing of a duckweed. (Throughout this paper the term "frond" is used to refer to a *single* segment of a duckweed plant.)

1. Frond with 1-many roots, much flattened, only the lenticular turions rootless; reproductive pouches 2
   2. Frond with 2-many roots and 4-many nerves, broadly obovate to ovate . . . . . SPIRODELA POLYRHIZA
   2. Frond with 1 root and 1-3 nerves
      3. Margin of frond entire; nerves 3; upper surface of frond emersed; fronds not in chainlike clones . . . . . LEMNA MINOR
      3. Margin of frond dentate, serrate, or erose; nerve 1, with occasionally 2 obscure lateral nerves; frond submersed or, only when fertile, most of the upper surface emersed; fronds usually in chainlike clones . . . . . LEMNA TRISULCA

1. Frond without roots, spherical to hemispherical or ellipsoid; reproductive pouch 1
   4. Upper surface of frond convex, or a small portion slightly flattened and roughened with several very minute central papillae; apex blunt, not raised; frond not punctate; cells of frond uniformly inflated . . . . . WOLFFIA COLUMBIANA
   4. Upper surface of frond smooth, flattened, with a raised acute apex (best seen in side view); frond usually brown-punctate, especially when dead; cells inflated in lower portion of frond, progressively smaller and more compactly arranged toward upper surface. .WOLFFIA PUNCTATA

SPIRODELA

1. *Spirodela polyrhiza* (L.) Schleiden (figs. 1a, 1b, 7)

Fronds solitary, or few attached by short deciduous stipes, usually 3-7 mm long, 3-6 mm wide, occasionally somewhat larger, broadly obovate to almost ovate, asymmetric, basal portion usually somewhat depressed dorsally and flatter than the rest of the frond; dorsal surface glossy dark green to medium green, often suffused with red and with a prominent red dot at the centrum, from which radiate 5-16 nerves, margin red; ventral surface reddish purple to pale red; roots 3 or, more often, numerous.

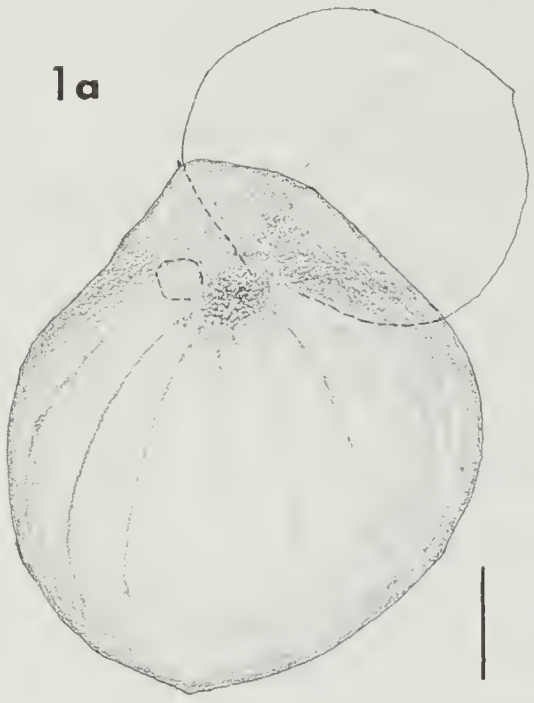
Flowers have very rarely been observed on plants of this species. We have found flowers on one of our Minnesota collections (Clearwater Co., small pond just west of Lake Itasca P. O. on Minn. 31 to Zerkel, ½ mile east of the Mississippi River, 23 July 1967, *Clark and Williams 2025,* LAF). The flowers in this collection were invariably borne in the *right*-hand pouch of the third frond of a clone of four fronds, the first being a germinated turion. No fruit could be found in subsequent collections from the site. This species overwinters and survives periods of drouth usually by the production of small, starch-filled, rootless fronds—the turions (fig. 1a) (the "winter buds" or "hibernacula" of some authors). When conditions are again favorable for growth, as in the spring, each turion expels a small bubble of gas that causes it to rise to the surface of the water, where it germinates quite rapidly. Jacobs (1947) gives an excellent account of *Spirodela polyrhiza* turions based upon his Ph.D. work at the University of Minnesota.

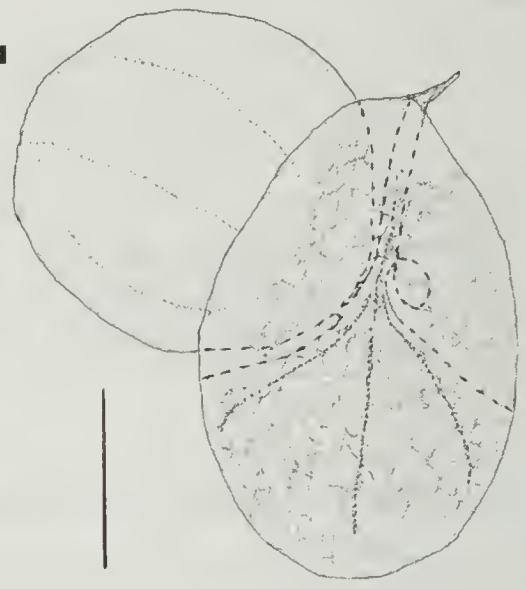
Spirodela punctata Meyer (incl. *S. oligorrhiza* (Kurz) Hegelm.) can reasonably be expected to appear in the Minnesota flora, since this primarily Asiatic species has been collected in widely separated localities in both the United States and Canada (Daubs, 1965; McClure, 1964, p. 5). Its first observed United States introduction was in Missouri in 1930. It is distinguished from *S. polyrhiza* by the presence of 2-5 roots (rarely 1), narrowly obovate shape, absence of a red dot on the upper surface, and generally smaller size. It differs from *Lemna minor* also by having a red dorsal upper margin and being generally more asymmetric.

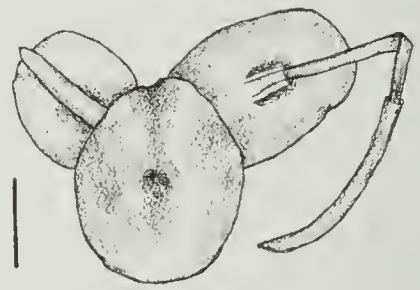
LEMNA

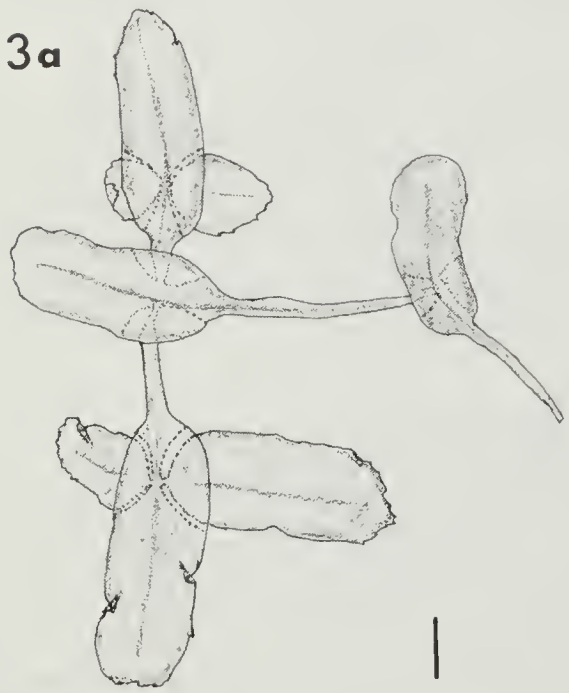
2. *Lemna minor* L. (figs. 2a, 2b, 8)
   Syn.: *L. obscura* (Austin) Daubs; *L. perpusilla* of Minnesota references, not Torr.

Fronds solitary, or few attached by short deciduous stipes, the stipes hyaline and not appearing continuous with the dorsal surface; fronds elliptic to obovate,









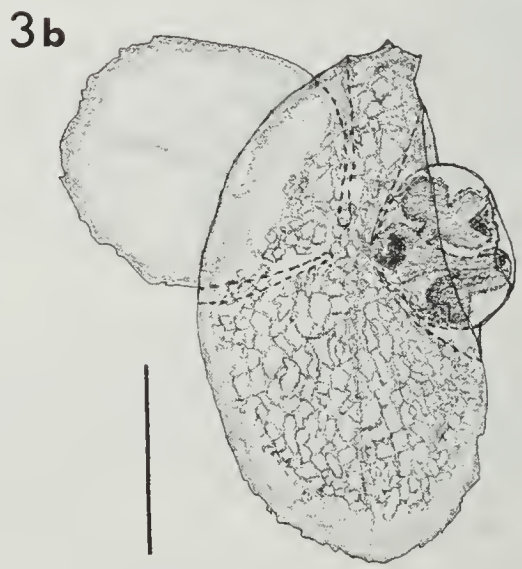


Fig. 1a. *Spirodela polyrhiza,* dorsal view, clone of two fronds.
Fig. 1b. *Spirodela polyrhiza,* dorsal view, germinating turion.
Fig. 2a. *Lemna minor,* dorsal view, clone of two fronds.
Fig. 2b. *Lemna minor,* ventral view, germinating turion.
Fig. 3a. *Lemna trisulca,* dorsal view, clone of several fronds.
Fig. 3b. *Lemna trisulca,* dorsal view, clone of two fronds, the larger, with a spathe and flowers produced from the left-hand reproductive pouch.

(The vertical lines represent a length of 1 mm.)

symmetrical to slightly asymmetrical, more asymmetrical when fertile, 2-4 mm long, 1.1-2.5 mm wide, green to pale green, often suffused with red, margins very narrow, hyaline; nerves 3, somewhat obscure, root 1.

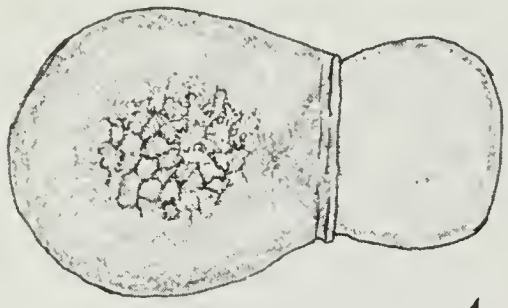
This species is quite variable and exhibits a large diversity of vegetative forms, most of which are ecological or seasonal in origin.

Lemna gibba L. has been reported from Minnesota by Daubs (1965) on the basis of a collection (*Moyle 2331;* cited incorrectly as *2321* by Daubs) made in Douglas County (specimen in herb. UC; duplicate at the Lake Itasca Biological Station). This collection, in flower and fruit, has been examined by us and is clearly *L. minor,* as the seeds are solitary and shallowly ribbed and the fruit is not winged. The seeds and fruit in this collection are typical of all fertile specimens of *L. minor* examined by us. *Lemna gibba* normally has 2-6 seeds (rarely 1) per fruit, the seeds are distinctly ribbed, and the fruit is winged.

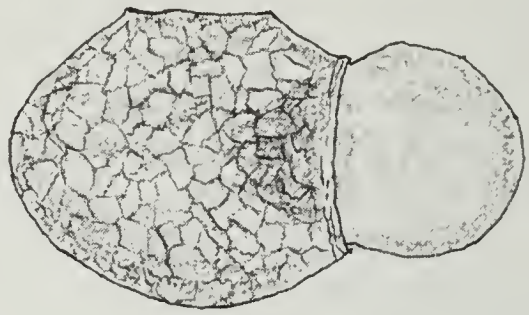
Lemna obscura is being placed in synonymy by us, as we find that the characteristics which are supposed to distinguish this species from *L. minor* (i.e., smaller size, amount of convexity, amount of pigmentation, and relative prominence of air spaces) intergrade freely in natural habitats. These characteristics also have been observed to vary greatly in plants in axenic and other cultures under a wide range of controlled environmental conditions (Landoldt, 1957; McClure, 1964; Harrison, 1964; Spooner, 1967; and others). We found no fruit, even on fronds that compared well vegetatively with descriptions of *L. obscura,* definitely having the "broad shoulders" that are also, according to Daubs, definitive for this species. We have also attempted to examine the only fruiting collection of *L. obscura* (Florida, *Godfrey 55745,* UC and FSU) cited by Daubs, but the curators of the herbaria cited were not able to locate the specimens. Clark (1968) examined many Louisiana specimens of *Lemna* which, vegetatively, fit well Daubs' description of *L. obscura,* a "species" that Daubs credits to Louisiana. However, the fruits and seeds of these specimens resemble those of *L. minor.* Thus we have been unable to verify Daubs' assertion that *L. obscura* is distinguishable from *L. minor* by its fruits and seeds. The senior author has found, during the preparation (in collaboration with Gene J. Gonsoulin) of a paper on the fruits and seeds of North American Lemnaceae, that these structures are more variable than published reports would indicate.

Lemna minor and *L. obscura* can reportedly be separated on the basis of their comparative flavonoid chemistry (McClure, 1964), but even this technique may not be completely reliable. Ball, Beal, and Flecker (1967) have recently shown that chromatographic pattern variation in two species of *Spirodela* can be induced by controlled variation of culture conditions.

Careful examination of all available Minnesota *Lemna* collections, including many identified as *L. perpusilla,* and abundant living material of Minnesota duckweeds, has convinced us that *L. perpusilla,* although reported to be a part of the Minnesota flora, does not occur in the state. All Minnesota specimens that we have seen identified as *L. perpusilla* have been annotated by us as *L. minor.* Those authors who have ascribed *L. perpusilla* to Minnesota have used characteristics of the root cap to distinguish this species among Minnesota entire-margined *Lemna.* The shape of the root cap in these plants is highly variable and is, in our opinion, a feature of little taxonomic value. *Lemna,* in axenic culture



4a



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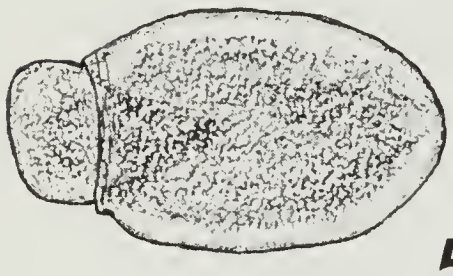

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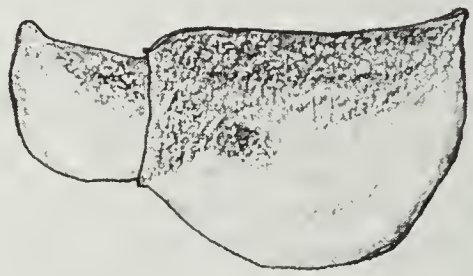

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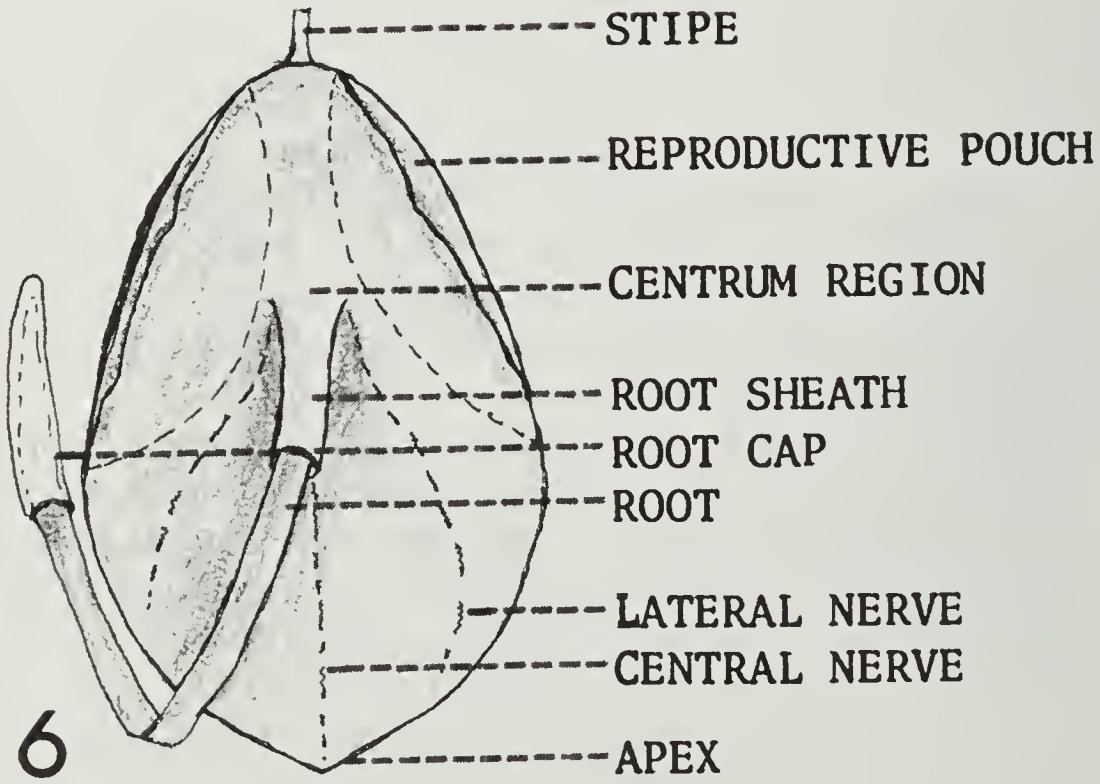


Fig. 4a. *Wolffia columbiana,* dorsal view, clone of two fronds.
Fig. 4b. *Wolffia columbiana,* lateral view, clone of two fronds.
Fig. 5a. *Wolffia punctata,* dorsal view, clone of two fronds.
Fig. 5b. *Wolffia punctata,* lateral view, clone of two fronds.

(The horizontal lines represent a length of 1 mm.)

Fig. 6. Diagrammatic drawing of a single duckweed frond.

(McClure, 1964, p. 57, sub *L. obscura*), produced root caps that varied "from obtuse to acute even within a single clonal culture." True *L. perpusilla* is clearly distinguished from *L. minor* by lateral wings on the root sheath, distinct apical and usually central dorsal papillae, and clear differences in flower and fruit, the spathe being open and much reduced and the seed narrow and strongly ribbed. The spathe of *L. minor* almost completely surrounds the immature flowers, being irregularly ruptured at its apex by the developing flowers, and the seed is smooth to very shallowly ribbed. *Lemna perpusilla* produces flowers and fruits more commonly than most other species of North American Lemnaceae, so these characteristics are usually not difficult to observe when the species is collected.

3. *Lemna trisulca* L. (figs. 3a, 3b, 9)

Fronds usually 3-30, attached in chainlike clones, each frond with a stipe up to 14 mm long, the stipe continuous with the body of the frond; fronds submersed except when in flower, 4-10 mm long (not including the stipe), 1.4-4 mm wide, pale green or green, occasionally reddish; apical margin thin, dentate, serrate, or sometimes erose; central nerve 1, continuous through the centrum into the stipe, occasionally 2 obscure lateral nerves in robust fronds; root 1, often deciduous.

Identification, particularly of dried specimens, can be somewhat more difficult when the plants are in flower. In flowering condition, the fronds are shorter, thicker, and suffused with red, and float on the surface of the water. These fertile fronds (fig. 3b) may be distinguished from *L. minor* by the non-entire margins, by the blunt continuous stipe (the stipe of *L. minor* being pointed and well differentiated from the frond), and by the more lateral position of the reproductive pouches. Flowers are common but not abundant on Minnesota specimens of *L. trisulca;* fruits are uncommon.

WOLFFIA

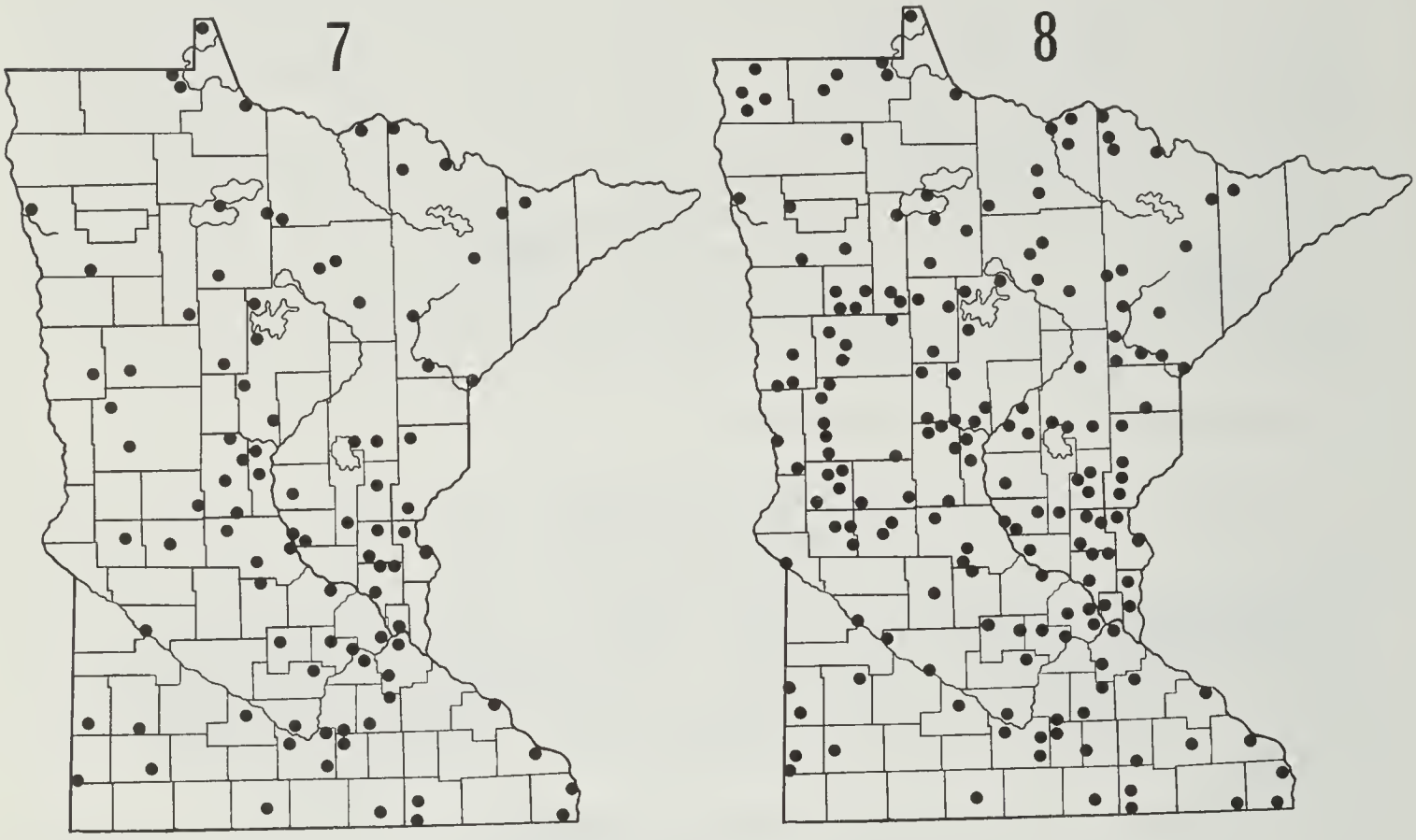
4. *Wolffia columbiana* Karsten (figs. 4a, 4b, 10)

Fronds globose to broadly ellipsoid, 0.7-1.4 mm long, truncate at the solitary reproductive pouch; dorsal surface convex, often with a few minute papillae; frond floating at the surface of the water, with only a small portion of the dorsal surface of the frond emersed, no clear distinction between dorsal surface and sides; cells not punctate; inner cells of frond uniformly large and somewhat inflated.

Several Minnesota collections have been found in flower, but no fruits were present in these. Seeds evidently belonging to *Wolffia* sp. were found in one collection (Blue Earth Co., Cottonwood Lake, Medo Twp., 18 Sept. 1958, *Moore and Bernardini 24307,* MIN), but no flowers or attached fruits could be found on the plants.

5. *Wolffia punctata* Grisebach (figs. 5a, 5b, 10)

Fronds ellipsoid to narrowly ellipsoid, 0.6-1.2 mm long, truncate at the solitary reproductive pouch; dorsal surface smooth, flat or slightly convex, with



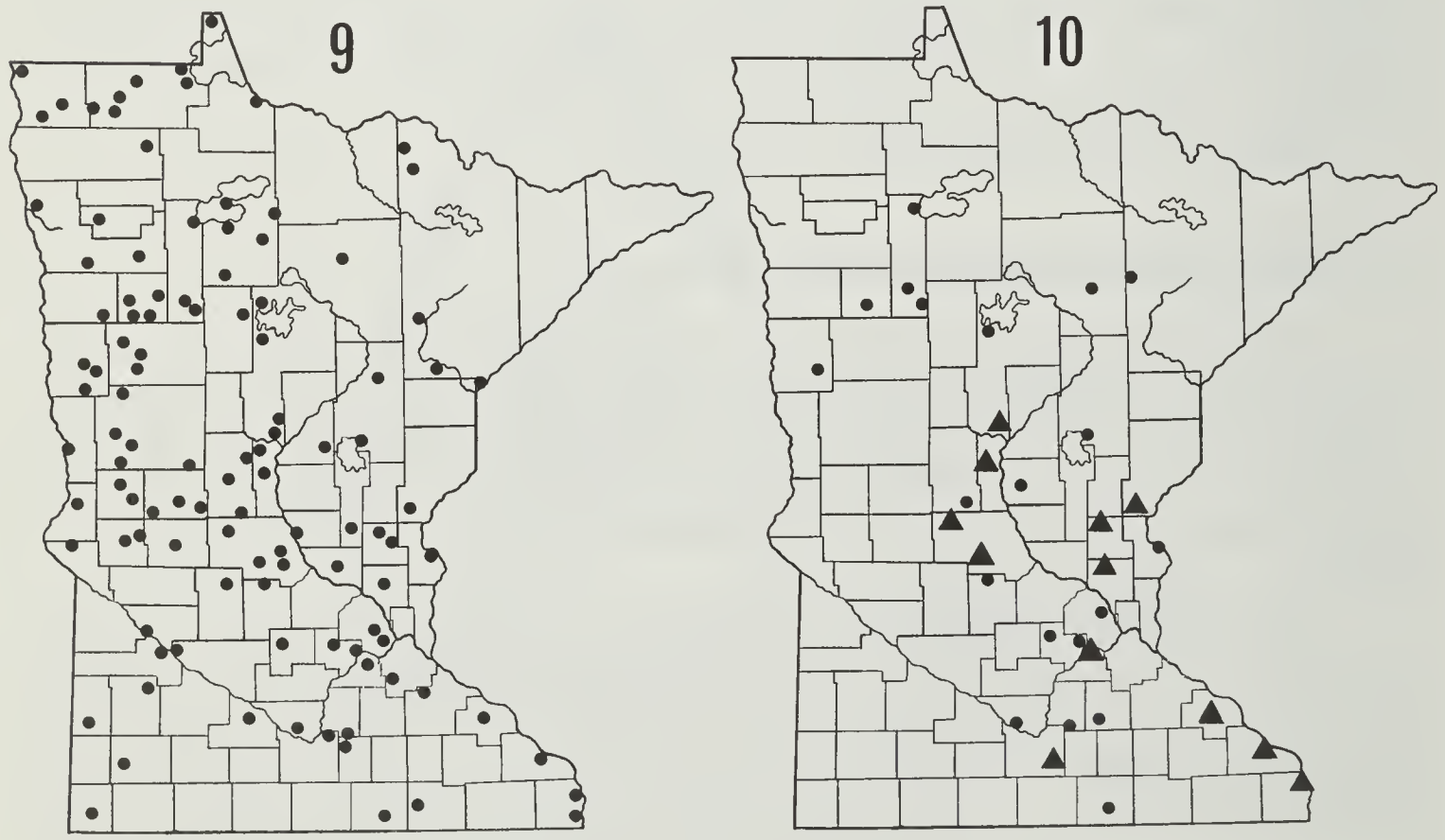


Fig. 7. *Spirodela polyrhiza,* documented distribution in Minnesota.
Fig. 8. *Lemna minor,* documented distribution in Minnesota.
Fig. 9. *Lemna trisulca,* documented distribution in Minnesota.
Fig. 10. *Wolffia,* documented distribution in Minnesota: circles–*W. columbiana;* triangles–*W. columbiana* and *W. punctata* together.

a raised acute apex; frond floating at the surface of the water with the entire, flattened, dorsal surface emersed, and with a clear distinction between this surface and the sides; cells usually uniformly punctate; inner cells of frond progressively smaller and less inflated from ventral to dorsal surface, causing the upper 1/3 of the frond to be quite darker than the lower portion.

This species has not yet been reported in flower in Minnesota. We saw no collection that consisted of *W. punctata* alone; in every collection of it at least one other duckweed—*W. columbiana*—was present. In contrast, several collections contained *W. columbiana* as the only representative of *Wolffia.*

ACKNOWLEDGMENTS

We are grateful to Dr. Gerald B. Ownbey and Dr. Paul H. Monson for loan of specimens; to Dr. Ernest O. Beal for several valuable suggestions; and to Mr. Gene J. Gonsoulin for assistance with the illustrations.

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Publications of Interest

THE THIRD WAVE. . .America's New Conservation. U. S. Department of the Interior Conservation Yearbook No. 3. [1967?] 128 pp. $2.00 (Supt. of Documents, Government Printing Office, Washington 20402). While the Department of the Interior Yearbooks will never seriously rival Sierra Club publications, this is a colorful and significant report on federal conservation activities–despite the inevitable political overtones. The color picture essay "Man Was Here" is particularly moving, in a depressing sort of way. Michigan readers may regret the omission of Isle Royale from the color essay "A Parade of National Parks," but there are several photos from the Kalamazoo Nature Center in the concluding chapter.

OUTDOORS USA. The Yearbook of Agriculture 1967. 408 pp. Advertised by the Department of Agriculture as "Big as all outdoors in scope, this is a handbook of conservation, consumer's guide to outdoor recreation, and primer on beautification." The aim of the Interior and Agriculture yearbooks is clearly to place the federal government on the side of the angels regarding conservation. Botanical Club members will find much of interest in this volume, even though many would prefer a little less stress on "recreation" and a little more on wild lands. Available for $2.75 from the Superintendent of Documents (Washington 20402) or without charge from one's congressmen.

BIBLIOGRAPHY & NATURAL HISTORY. Essays Presented at a Conference Convened in June 1964 by Thomas R. Buckman. University of Kansas Publications Library Series 27. 1966. 148 pp. $5.00 (Univ. of Kansas Libraries, Lawrence, Kansas 66044). There are enough identified botanical bibliophiles among our subscribers to justify calling attention to this collection of essays ranging from W. T. Stearn's excellent "The Use of Bibliography in Natural History" (which includes among other topics a fine presentation on Linnaeus and his "binomial system" for literature citations) to Jerry Stannard's extensively documented "Early American Botany and its Sources." Illustrated botanical works in China and Japan and a study of Linnaeus are among the several other subjects covered in this volume.

THE SPRING BEAUTIES (*CLAYTONIA*) IN MICHIGAN

Edward G. Voss
Herbarium, The University of Michigan, Ann Arbor

Confusion over our two species of *Claytonia* has existed ever since (as well as before) Asa Gray began his illustrious botanical career. In his incomplete autobiography, Gray wrote that in the spring of 1828 [at the age of 17 and three years before receiving his M. D. degree] , while serving his medical apprenticeship with Dr. J. F. Trowbridge of Bridgewater, New York,

> . . .I sallied forth one April day into the bare woods, found an early specimen of a plant in flower, peeping through dead leaves, brought it home, and with Eaton's "Manual" without much difficulty I ran it down to its name, Claytonia Virginica. (It was really C. Caroliniana, but the two were not distinguished in that book.) I was well pleased, and went on, collecting and examining all the flowers I could lay hands on; and the rides over the country to visit patients along with my preceptor, Dr. Trowbridge, gave good opportunities. I began an herbarium of shockingly bad specimens.[1]

Thus did *Claytonia* launch the botanical career of the man who was to become the leading botanist of the nation; the author of numerous textbooks, manuals, floras, and monographs; and the first professor to be appointed to the faculty of the University of Michigan after it was reorganized in Ann Arbor in 1837.

The original *Asa Gray Bulletin,* published for the Gray Memorial Botanical Chapter of the Agassiz Association,[2] carried several short notes on *Claytonia* e. g., in Nos. 5 & 6. 1894) and it was even suggested that *C. virginica* "be selected as the Chapter flower." (Asa Gray Bull. 3(8): 6. 1895.) When this selection was proposed, it was observed that "Either species would serve our purpose, but [*C. virginica*] is most common. The range of both is limited."

The ranges are indeed limited, and have not been well understood in the Great Lakes region. The data here presented on the occurrence of the two species in Michigan (with a few other observations) will add another dimension to the studies cited under "References" on the taxonomy and cytology of *Claytonia* which seem to indicate a resurgence of interest in the genus during the past few years. The map in Fig. 1, indicating the location of Michigan counties, will aid in understanding the geographic remarks.

The more northerly wide-leaved spring beauty, *Claytonia caroliniana,* although described as long ago as 1803, was not always recognized by early botanists or was considered to be a variety [var. *latifolia* Torr.] of *C. virginica,* the more southern narrow-leaved spring beauty. Both species have, however, been

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[1]See pp. 14-15 in "Autobiography," Chapter I of Letters of Asa Gray, ed. by Jane Loring Gray (Macmillan, 1893). Gray's memory evidently lapsed slightly when recording these autobiographical notes, for the two species were clearly distinguished in Eaton's Manual (both 3rd ed., 1822, and 4th ed., 1824), with "caroliniana Mx." as a footnote on *C. spatulata,* the name used by Eaton.

[2]See Harley H. Bartlett, History of the Gray Memorial Botanical Association and the Asa Gray Bulletin, Asa Gray Bull. N. S. 1: 3-22. 1952. Botanists from Michigan were particularly active in the Gray Memorial Botanical Chapter.

admitted in all editions of Gray's Manual, since 1848, and in almost all other manuals published during the same period. But some collectors, originally familiar with only *C. virginica,* have been slow to realize that another species also occurs in this region. The first published report of *C. caroliniana* from Michigan[3] appears to have been by Coleman in 1874, but the species was not included in the Wheeler and Smith list of 1881. By 1892, both species were included in the Beal and Wheeler list, and both were in Beal's "Michigan Flora" of 1905. The latter two lists properly indicated that *C. caroliniana* was restricted to the northern part of the state, but erred in giving the range of *C. virginica* as "throughout," thus obscuring the distinctive and essentially complementary patterns of the two species (cf. Figs. 4 & 5). Early reports of *C. virginica* from northern Michigan are all almost certainly errors for *C. caroliniana.* I know of no previously published records for *C. virginica* north of St. Clair and Kent counties which are supported by specimens.

At the time of a previous summary (Voss, 1957) of the distribution of *Claytonia* in the state, there appeared to be a belt one to three counties wide across the middle of the Lower Peninsula, from which neither species was known. North of this strip was only the wide-leaved species; south of it, only the narrow-leaved one. Such a distinction in ranges seemed "too good to be true," and I suggested that "Further collecting in the two or three tiers of counties in the center of the Lower Peninsula, between the present known ranges of the two species, should be profitable."

Following my own advice without delay, in 1957 I pursued spring beauties, particularly across the middle of the state west of Saginaw Bay. On the major excursion for this purpose (May 3-5), Thomas R. Detwyler was a most enthusiastic and stimulating companion in the field, and we explored the "Thumb" area southeast of Saginaw Bay the following spring. Numerous other students and colleagues accompanied other trips during those years and the subsequent ones, and to all of them I am grateful for the sharp eyes and willingness to look into "just one more woodlot before dark" which have resulted in over 100 collections of *Claytonia* since 1957. (If this genus was so poorly represented in herbaria from certain parts of the state, it could be assumed that other spring plants were likewise under-represented, so that general collecting was also done on all field trips.)

Plants of *Claytonia* are usually so abundant in the field that one readily sees a great range of variability.[4] To some extent, this may be associated with extraordinary cytological diversity, as recently summarized by Lewis, et al.

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[3]The early Michigan lists referred to are as follows:

Coleman, N. 1874. Catalogue of Flowering Plants of the Southern Peninsula of Michigan, with a Few of the Crytogamia [sic]. Kent Sci. Inst. Misc. Publ. 2. 49 pp.

Wheeler, Charles F., & Erwin F. Smith. 1881. Michigan Flora. Rep. St. Hort. Soc. Mich. 10: 427-529. [Reprinted with different title page and repaged 1-105.]

Beal, W. J., & C. F. Wheeler. 1892. Michigan Flora. Rep. St. Bd. Agr. Mich. 30: 471-650. [Reprinted and repaged 1-180.]

Beal, W. J. 1905 ["1904"]. Michigan Flora. Rep. Mich. Acad. 5: 1-147.

[4]As early as 1876, C. F. Wheeler (Bot. Gaz. 2: 65) noted considerable variation in *C. virginica,* presumably at Hubbardston, Michigan.

(1967b). Chromosome numbers in *C. virginica* throughout its range vary from 2n = 12 to ca. 191. Numbers may vary within a single population—and even in a single individual (Lewis, 1962). Artificial hybridization between plants known to differ in chromosome number has been successful in producing offspring (Rothwell, 1959, p. 355). Higher polyploids of *C. virginica* were found in the area of St. Louis, Missouri, to be separable morphologically from lower polyploids by the broader leaves of the former (Lewis, et al., 1967a).

A thorough study of chromosomal behavior in Michigan Claytonias would be highly desirable. Buds preserved from plants in the remarkable ravine in Oceana County (described below) where both species occur were examined through the kindness of W. H. Wagner, Jr., but the material was too old on May 3, 1964, for meiotic figures.[5] I would be happy to supply as detailed directions

Fig. 1. Michigan, indicating location of counties.

[5]Lewis (1967, p. 109) reports that meiosis in *C. caroliniana* may occur under the snow very early in the spring.

as possible to the sites where both (or either) species occur, to anyone with a desire to carry out for this region—but involving two species—the kind of extensive study done for *C. virginica* alone by Lewis, et al. (1967a) in Missouri or Rothwell and Kump (1965) in the New York area. The only Michigan counts given by Lewis, et al. (1967b) are from Berrien County: 2n = 24, 25, 26.

CLAYTONIA VIRGINICA

Claytonia virginica L. (Fig. 2) ranges from Georgia, Louisiana, and eastern Texas north to Nova Scotia, New Brunswick, southern and western New England, southern Quebec and Ontario, the Lake States (becoming absent northward in Michigan, Wisconsin, and Minnesota), Nebraska, and Oklahoma. One of 15 North American species in the genus, it is most closely allied to *C. caroliniana,* the only other species in the states east of the Great Lakes, from which it is normally distinguished readily by the shape of the cauline (stem) leaves. These are linear to narrowly elliptical in *C. virginica,* characteristically about 13-17 times as long as broad, with no definite petiole. The basal leaves, arising directly from the underground corm, are often larger and broader.

Normally there are two opposite cauline leaves, but aberrant individuals with three leaves are occasional, as also in *C. caroliniana;* and rarely there may be a flowering axillary branch (e. g., 5656, Tuscola Co.; 9267, Allegan Co.; 7911, Clare Co.; 11445, Ottawa Co.; & McVaugh 11224, Branch Co.).

Fig. 2. *Claytonia virginica,* showing characteristic linear leaves. Photographed by James S. Pringle at the Cootes' Paradise Santuary of the Royal Botanical Gardens, near Hamilton, Ontario.

Broad-leaved plants of *C. virginica* may be mistaken for *C. caroliniana,* especially if one is not familiar with the characteristic rhombic or diamond-shaped blades of the latter. Davis recognizes *C. virginica* f. *robusta* (Somes) Palmer & Steyermark as such a large elliptic- to lanceolate-leaved form, with a range from Indiana to Iowa and Missouri. What could surely be referred to this form was found with the normal form by M. F. Tessene on a trip with me in Auglaize County, Ohio (floodplain forest along Auglaize River by Buckland Quarry, ca. 4 mi. NW of Wapakoneta, April 23, 1967. 12408, MICH, OS). The leaves of the Ohio plants range up to 18 mm broad by 95 mm long (some slightly narrower ones to 120 mm long), or less than 6 times as long as broad. Other robust plants are discussed below under certain records for *C. caroliniana.*

In Michigan, *C. virginica* is extremely local beyond T20N; i. e., the northern edges of Mason, Lake, Osceola, Clare, Gladwin, and Arenac counties, or approximately 44°10' N. lat. The only collections from north of this line (see Fig. 4) are as follows:

ROSCOMMON CO.: common in low deciduous woods, N½NW¼ sec. 17, S½ Richfield Tp., ca. 5.5 mi. SW of St. Helen, May 14, 1961, with Richard C. Crickmer. (9813) *Carpinus caroliniana* and *Viola fimbriatula,* both at the northern edge of their range in the Lower Peninsula, were in the same woods.

Fig. 3. *Claytonia caroliniana,* showing characteristic wide leaves. Photographed by Frederick W. Case, Jr., near Lewiston, Michigan, May 2, 1964.

ALCONA CO.: abundant in young beech-maple woods near center of S edge of sec. 26, T27N, R5E, ca. 1 mi. SE of Curran, May 10, 1957, with R. M. Schuster. (3533).
MACKINAC CO.: Round Island—discussed below under "Mixed Sites."
DELTA CO.: occasional in deciduous woods near E edge of secs. 26-35, T41N, R23W, ca. 7 mi. NW of Gladstone, May 24, 1958. (5965) John H. Beaman first spotted the plants at this site, which remains the only one known on the mainland of the Upper Peninsula.

CLAYTONIA CAROLINIANA

Claytonia caroliniana Michx. (Fig. 3) ranges from Prince Edward Island, Newfoundland, and Gaspé west across Quebec (cf. Doyon & Lavoie, 1966), Ontario, including the north side of Lake Superior, and the northern portions of Michigan and Wisconsin, to northeastern Minnesota (Cook and St. Louis counties), south through New England and New York to Pennsylvania and in the Appalachian Mountains to eastern Kentucky, North Carolina, Tennessee, and Georgia; also in the Ozark Mountains of northwestern Arkansas, according to Davis (1966).[6] A map of the distribution, naturally incomplete but better than many statements on this species, was published by Braun (Rhodora 39: 202. 1937), who has stated to me (December, 1953) that she does not believe the southwestern Ohio reports (Schaffner, Ohio Jour. Sci. 38: 213. 1938).[7] This map included only one Michigan record, on the Keweenaw Peninsula; Fig. 5 covers this state more thoroughly.

The cauline leaves of *C. caroliniana* typically have a distinctive broad, more or less diamond-shaped or rhombic to somewhat ovate blade and a definite petiole. The total length (including petiole) is characteristically about 3-5 times the width,

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[6]Not fitting into this pattern is a collection cited by Davis (1966) as "Hanover, Jefferson Co., Indiana, *Young* (MICH)"; I am more certain that the locality is wrong than the identification, but question both. The printing on the label reads at the top "Herb. of A. H. Young" and at the bottom "Hanover, Ind., 18 " and is in a style common on labels of the last quarter of the previous century. The bottom line is, I think, merely the address of the collector; in addition to the name "Claytonia caroliniana" there has been written "La Fayette" on the label, and this is presumably the locality. The date is given as April 1877—the year when Young moved to Lafayette (cf. Natl. Cycl. Am. Biogr. 2: 397 & 22: 17). There are only two plants, so far out of the otherwise known range of *C. caroliniana* that I would echo the skepticism of Deam (Fl. Indiana, pp. 1044-1045. 1940) regarding Indiana records and suggest that these broad-, but scarcely rhombic-leaved plants may be only forms of *C. virginica.* Jones (Am. Midl. Nat. 34: 279. 1945) similarly disposed of Illinois records of *C. caroliniana.* See also footnote 7.

[7]Such reports, and others, of *C. caroliniana* from areas south and west of what is apparently its range are presumably based on large, wide-leaved forms of *C. virginica,* as suggested in the previous footnote. Whether these result from genetic or ecological factors, or both, is not certain. The Bartlett collection of *C. virginica* f. *robusta* cited by Davis (1966, p. 196) from Marion Co., Indiana, came from Little Eagle Creek, April 24, 1904, and bears the notation by the collector: "Ecological form developed where the natural soil (black forest loam) is covered with 4-5 inches of drifting sand." There is a single plant, with cauline leaves 20 x 108 and 21 x 113 mm and one basal leaf 27 x 150 mm. Broad-leaved plants from southern Minnesota have been questioned by Morley (Spring Fl. Minn., p. 105. 1966). A collection from Oceana Co., Mich. (9391, with T. R. Detwyler, near center sec. 25, Benona Tp., May 14, 1960) from beech-maple woods only 2 miles south of the ravine where both species occur resembles f. *robusta,* the largest cauline leaves being 15-17 mm broad and about 168 mm long. Some of the plants from Round Island (12438) are similarly robust.

and this ratio is much more consistent than any absolute measurements (see under "Distinguishing Characters," below). Plants from higher elevations in the southern Appalachians have recently been recognized as var. *spatulifolia* (Salisb.) Lewis (1966); these have much smaller and proportionally somewhat narrower leaves than typical var. *caroliniana;* judging from Lewis' figures, they may run close to 8 times as long as broad, but as they are much shorter than those of equal width in *C. virginica* there should be no confusion. Further investigation of small-leaved plants might be fruitful. Very small-leaved plants were found by L. O. Gaiser in 1960 in a woods near Thedford, Ontario (see below); the leaves of some, though not all, of these resemble Lewis' figures of var. *spatulifolia.* Similar very small-leaved individuals have been collected, generally with larger ones, at several Michigan localities (e.g., 3427, Ogemaw Co.; 3529, Alcona Co.; 6099, Baraga Co.; 11456, Oceana Co.; & Parmelee 2221.1, Houghton Co., MSC).

Cytologically, *C. caroliniana* also displays extensive aneuploidy and polyploidy; it has known 2n numbers ranging from 16 to 38 (Lewis, 1967; Lewis, et al., 1967b). Perhaps it would show a greater range than this if it were investigated as thoroughly as *C. virginica,* although its more restricted geographic distribution suggests less chromosome diversity as well.

In Michigan, *C. caroliniana* is definitely northern, evidently ranging a bit farther south near Lake Michigan and Lake Huron than in the interior (Fig. 5). The southernmost localities are discussed below under "Mixed Sites." The species was listed by Billington (Pap. Mich. Acad. 4: 96. 1925), in addition to *C. virginica,* from "Climax forest" at Warren Woods, in Berrien County, the southwesternmost county in the state. Warren Woods is not generally a location for northern plants; quite the contrary, it is the site for several species of southern affinity known from few if any other places in Michigan (e. g., *Diarrhena americana, Uniola latifolia, Carex davisii, Trillium recurvatum, Chaerophyllum procumbens*). Billington's collections labeled as *C. caroliniana* consist of 5 specimens, on two sheets (WUD, BLH), both collected May 18, 1921. The cauline leaves range from 9.5 to 14.5 mm broad, from 58 to 114 mm long, and from 5.5 to 12 times as long as broad. Insofar as lower bracts are present (the WUD sheet lacks one raceme), they are herbaceous, supposedly a character for *C. virginica.* I consider these plants to be robust forms of that species. On May 2, 1964, I searched Warren Woods for Claytonias, with Ronald L. Stuckey and Chester W. Laskowski. We looked especially on the slopes and ravines, where a colony of *C. caroliniana* might possibly be sheltered, hiking completely around the upland area mapped by Billington as "Climax Forest," and angling across the upland. Normal *C. virginica* was everywhere. Some plants with slightly wider leaves than usual were found (11442, 11443, 11444), particularly in the narrow spaces between buttresses at the bases of large trees, but none really resembled *C. caroliniana* in leaf shape and they have all since been confirmed by R. J. Davis as *C. virginica.* Their leaves range from 8.5 to 15.5 mm broad, from 65 to 97 mm long, and from 4 to 10 times as long as broad.

DISTINGUISHING CHARACTERS

Leaf shape seems to be the best characteristic distinguishing *Claytonia caroliniana* from *C. virginica,* and is the only one given in the key by Davis

(1966). Other supposed differences sometimes mentioned in manuals do not seem, in my experience, consistent enough to be useful. There is apparently a slight phenological difference, as discussed under "Mixed Sites" below, but it is of little use in distinguishing species as there is great overlap. The dividing point in leaf shape has sometimes been stated as 6 times as long as broad; that is, plants with leaves more than 6 times as long are *C. virginica;* those with leaves less than 6 times as long are *C. caroliniana.* I find somewhat better discrimination at 8 times as long as broad (Voss, 1966) and the same figure is given by Davis (1966). Almost always, individuals are not near that dividing line, but there are occasional borderline plants and a certain amount of intuition may be needed to interpret ambiguous specimens.

The cauline leaves of Michigan plants of *C. virginica* apparently range from (6-) 8.5 to 19 (-36) times as long as broad. In some very unusual individuals, as cited above from Warren Woods, they may be as short as 4-5 times as long as

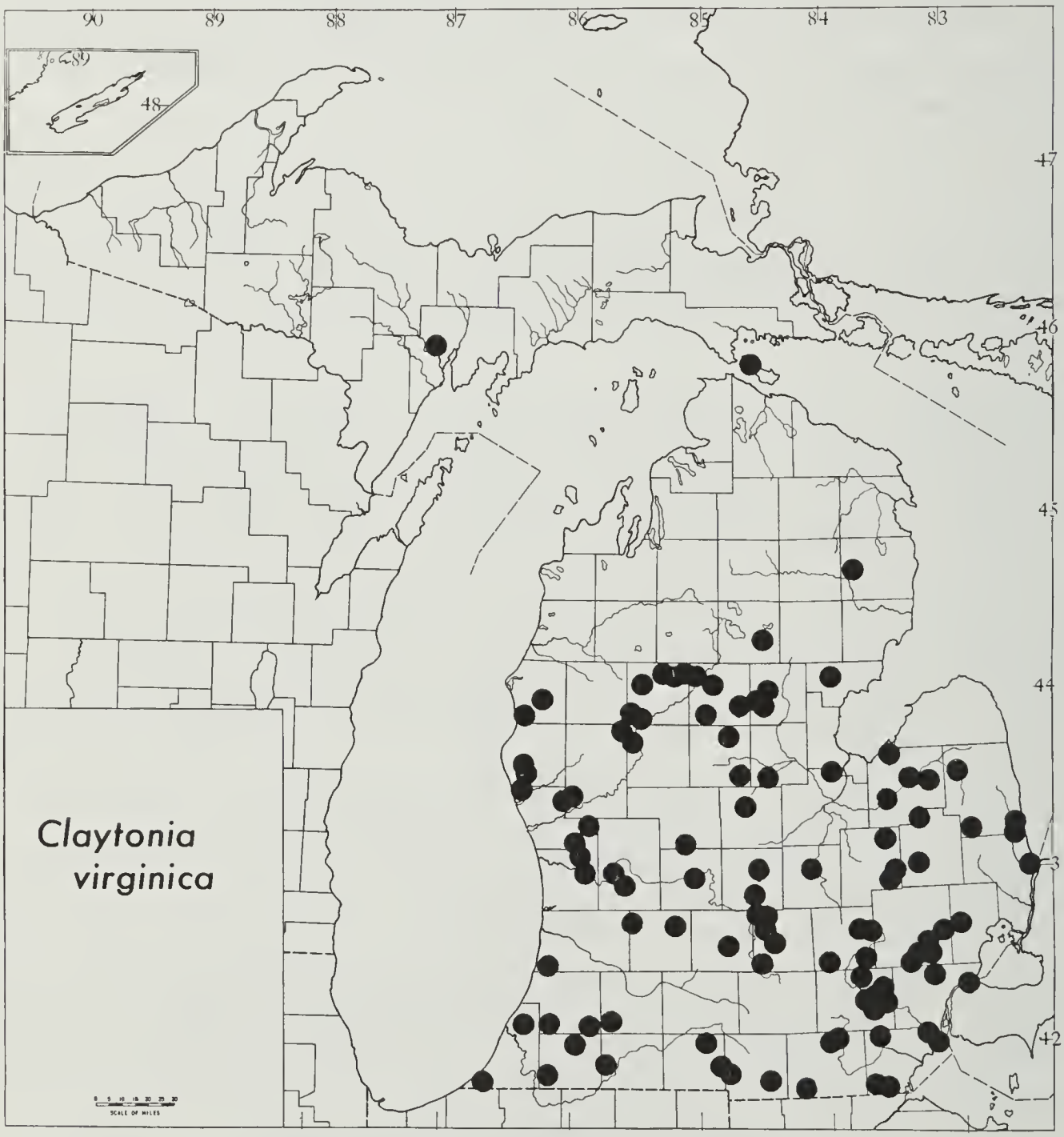

Fig. 4. Distribution of *Claytonia virginica* in Michigan, based on herbarium specimens examined. (A few collections are not mapped, where the additional dots would only add congestion in already well-collected areas.)

broad, but these are more elliptical or oblong than the characteristic shape of *C. caroliniana.* They range from 1.5 to 14 (-18) mm broad and from 24 to 140 (-168) mm long. The racemes bear (1-) 6-16 (-22) flowers. The seeds are about 2-2.5 mm long. The bract below the lowest pedicel is scarious or often partly herbaceous, rarely entirely herbaceous. Different stems from the same corm will vary widely in the degree of herbaceousness of the bract.

In *Claytonia caroliniana,* our specimens have leaves which run from 2.5 to 6.5 (-7.8) times as long as broad (or very rarely as much as 8.8 times as long, but these leaves with definite typical wide blade and unusually long petiole). The width ranges from (2.3-) 3.5 to 30 mm, and the length from 12 to 111 (-132) mm. The racemes bear (1-) 4-9 (-13) flowers. The seeds range 1.7-2.3 (-2.5) mm long. The bract below the lowest pedicel is, as in the other species, usually scarious or partly herbaceous, rarely entirely herbaceous.

In short, leaf shape appears to be the only useful distinguishing character. The seeds of Michigan specimens run, if anything, slightly opposite the size

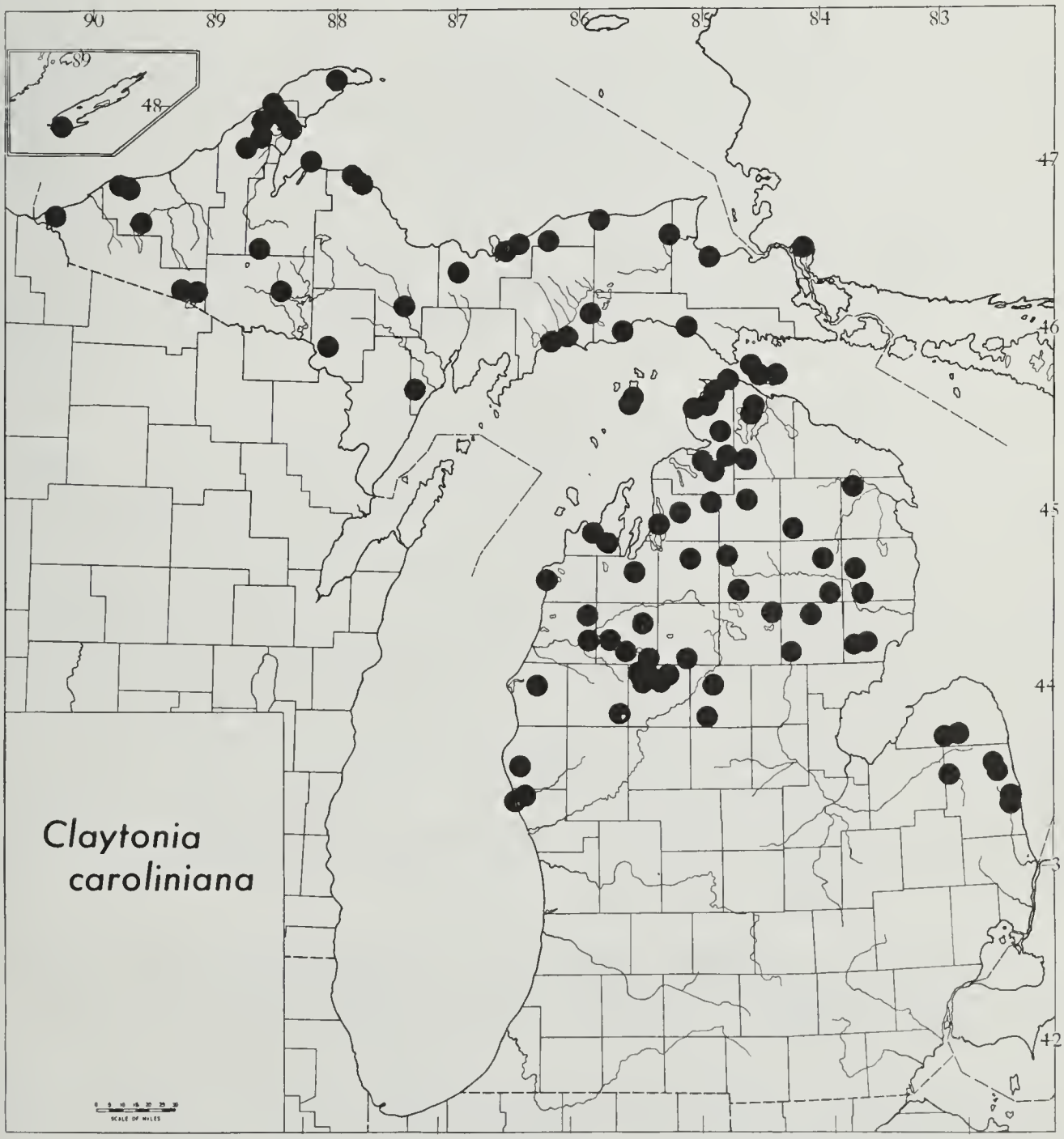

Fig. 5. Distribution of *Claytonia caroliniana* in Michigan, based on herbarium specimens examined. (As in Fig. 4, a few collections not mapped.)

difference indicated by Davis (1966) but the distinction is insignificant as the seeds are much more variable than his simple "2 mm" vs. "2.5 mm" would imply. The bract character used by Fernald (Man., ed. 8. 1950) is wholly unreliable in this region. Some plants of *C. virginica* do produce more flowers than any of *C. caroliniana,* but except for those few individuals the number of flowers in an inflorescence is not significant. The flowers are sometimes said to be smaller in *C. caroliniana,* but I have not noticed any distinction in the field; in fact, this species has the largest flowers I have seen on any herbarium material, as much as 27 mm across (Chippewa Co., rich upland maple woods of sections 28 & 33, T48N, R2E, Sugar Island, May 13, 1961. Hiltunen 2796, WUD). *C. virginica* may have a little wider ecological amplitude, at least in southern Michigan (where *C. caroliniana* does not grow), where it is found often in floodplain woods and thickets as well as upland sites; but as discussed below, the two species may grow under identical conditions.

MIXED SITES

Ordinarily, *Claytonia caroliniana* and *C. virginica* "seldom grow in the same immediate area" (Davis, 1966, p. 295). In those regions where both species are found, they are usually separated by such factors as habitat or elevation. Although most of his collecting was apparently conducted where *C. caroliniana* does not occur, Rothwell (1959, p. 357) stated, "In none of the localities studied were *C. virginica* and *C. caroliniana* found to be growing together, and in no case were populations discovered which appeared to be intermediate between the 2 species." Raymond (1949) suggested a distinct ecological separation in Quebec. On the other hand, Uttal (1964) reported *C. virginica* and *C. caroliniana* in two different but adjacent habitats in Virginia, with an apparent hybrid population on "the border between the two parental habitats."

Because the two species generally grow apart from each other, mixed collections are almost non-existent in herbaria. Davis (1966) implies that a collection from Truro, Nova Scotia (Prince & Atwood 859, GH, DS), may have been mixed, though segregated onto two sheets, for he cites the same number under both species. At the northwest edge of its range, *C. caroliniana* is found, as is *C. virginica,* near Duluth, St. Louis County, Minnesota, but the two are evidently not in the same woods (cf. Lakela, Fl. NE Minn., pp. 170 & 436, 1965). From that region, *C. caroliniana* ranges northeastward, north of Lake Superior, into Cook County (Butters & Abbe, Rhodora 55: 148. 1953) and the Canadian Lakehead; while *C. virginica* ranges only southward—in Wisconsin, north to Barron, Lincoln, and Kewaunee counties (Fassett, Spring Fl. Wis., ed. 3, p. 54. 1957; Seymour, Fl. Lincoln Co. Wis., p. 227. 1960).

The zone of overlapping ranges extends eastward from Minnesota and Wisconsin across Michigan and Ontario. Here, both species sometimes grow in the same woods, in exactly the same habitats—so close together, in fact, that the numerous fragile stems of the two species may become thoroughly intermixed as they rise through the ground from adjacent corms. In more numerous instances, the two species may grow within a few yards or at least a mile of each other.

The only observation reported by Davis (1966, p. 295) where the two

species grow near each other was at Newfound Gap in the Great Smoky Mountains National Park, where he found *C. virginica* blooming earlier on the east side than *C. caroliniana* on the west side. From this he generalized that when the two do grow "in the same immediate area, . . . *C. virginica* blooms earlier." My field experience is just the opposite. When the two species have been found growing together, in exactly the same situation, in Michigan and Ontario, *C. virginica* reaches its peak a little *later* (but see notes on the Ontario site, below). The difference is not great, and I judge only on the basis of mature plants, not having observed which species actually begins to bloom first in these sites. Plants of *C. caroliniana* in mixed populations have more mature flowers and fruit, and fewer buds, than those of *C. virginica.* Described below are the station in Ontario and the Michigan counties where the two species grow within a mile of each other, including sites where they are actually mixed.

ONTARIO: LAMBTON CO.: Early in 1964, just a year before her death, L. O. Gaiser wrote me of a woods near Thedford, in which both species grew, and sent me for examination all of her collections made there since 1960. (Her first collections, made April 27, 1959, are in the herbarium of the University of Guelph.) Specimens were first collected at this site by the late Newton Tripp, a naturalist of nearby Forest, on May 11, 1917 (specimens also now housed at Guelph). Dr. Gaiser relocated the woods, on the south side of Ridge Road, ca. ¼ mi. W of Conc. 6, Bosanquet Tp., or about 3 miles west of Thedford. Her careful survey of Lambton County failed to reveal any other locations for *C. caroliniana,* although *C. virginica* is common throughout the county. Dr. Gaiser's impression was that *C. virginica* was the less common species in this woods and occurred on higher ground.[8]

Large specimens of *C. virginica* were collected "on the higher ground, under beech tree. . .towards eastern edge of woods" May 4, 1960 (Gaiser 2576T, DAO, MICH); the label includes the notations "Found this species only on this higher ground. Flowering nearly over." Indeed, the plants are definitely more mature than those of *C. caroliniana* (Gaiser 2578T, DAO, MICH) collected the same date "in the low ground. . .not on high ground." Also collected at the same time were plants of *C. caroliniana* (2580T, DAO, MICH) with small petals and very small leaves (e. g., 3 x 15, 4 x 15, 5 x 23 mm). These were said to have come from low ground along with other *C. caroliniana.* Her May 12, 1961, collections, on the contrary, indicate a less advanced state for *C. virginica* (2954T, DAO, MICH), which is labeled: "NB On the higher ground, not with *C. caroliniana."* Considerable variation is displayed in the size of the leaves of *C. caroliniana* (2950T, DAO, MICH) collected on the same date; they range from 6 x 24 to 13 x 45 mm.

On May 27, 1966, Kenneth E. Guire and I relocated the woods while en route to the Michigan Botanical Club spring campout on the Bruce Peninsula. We

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[8]Dr. Gaiser's observations are taken from A Survey of the Vascular Plants of Lambton County, Ontario, by Lulu O. Gaiser, compiled by Raymond J. Moore (Plant Res. Inst., Canada Dep. Agr., 1966. 122 pp.); from the labels with her specimens; and from letters dated March 6, March 13, and May 2, 1964.

were too late, however, for Claytonias, and after much searching found only a few very old and shriveled leaves of *C. virginica.* Was it too late even for that much evidence of *C. caroliniana?* (We did find large colonies of the green violet, *Hybanthus concolor,* reported by Gaiser only from another location in the county.) I returned to the woods on May 6, 1967, with W. H. Wagner, Jr., David M. Hines, and M. F. Tessene, with better luck. We found Claytonias very scarce except toward the west end of the woods, where both species were common, especially *C. virginica. C. caroliniana* was in the northwest part of the woods, with *C. virginica* alone extending southward, without significant changes in elevation or exposure and with some dense colonies of both species mixed together. *C. caroliniana* (12410) appeared to be slightly earlier phenologically; at least it seldom had unopened buds, while plants of *C. virginica* (12409) generally still had some unopened buds. However, the oldest immature fruits appeared roughly to be of the same age in the two species, suggesting that they may have begun flowering at about the same time but that *C. virginica* (averaging, incidentally, a few more flowers per raceme) would last longer.

This Thedford site is only about 20 miles farther south than the southernmost stations for *C. caroliniana* in Sanilac County, Michigan, just to the west across the southern end of Lake Huron. But I have been unable to find both species closer than two or three miles from each other in that county.

OSCEOLA COUNTY, MICHIGAN: When serious pursuit of Claytonias was begun with T. R. Detwyler in early May of 1957, Osceola County, in the west-central Lower Peninsula, was the first in which we recognized both species. Extensive exploration of the numerous woodlots in the northern part of the county on May 5 revealed either no Claytonia or only one of the species in each. Apparently

Fig. 6. The narrow-leaved *Claytonia virginica* and broad-leaved *C. caroliniana,* growing together in the ravine (described in text) in Oceana Co., Michigan, May 3, 1964.

similar-looking woods, on what seemed to be the same moraine, would not necessarily have the same species, however, and hoped-for correlations with habitat did not materialize. On the east side of U.S. Highway 131, for example, in beech-maple woods back of Maple Hill Cemetery ca. 2 miles northeast of LeRoy, *C. caroliniana* was common. A mile south, on the west side of the highway, *C. virginica* was abundant in beech-maple-hemlock woods. In Highland Township, *C. virginica* was common at the edge of a grazed lowland elm-maple woods at the N edge of the NE¼ of Sec. 29. Half a mile north, in the SE¼ of sec. 20, *C. caroliniana* was locally abundant in a low elm-maple woodland; and a half-mile west, it was frequent in low aspen-elm woods in the NW¼ of sec. 29. Nearby, in a fine mature beech-maple-hemlock stand in the SE¼ of sec. 19, *C. caroliniana* was abundant.

In 1957, thought was not given to possible phenological differences. The evidence from 4 collections of *C. virginica* and 7 of *C. caroliniana* made on the same date in northern Osceola County (all from different woods) is that *C. virginica* is definitely later.

CLARE COUNTY: On May 4, 1957, our last collecting site before dusk—and a quick search for a campsite—was ca. 4 mi. NW of Harrison in a grazed upland maple woods in the SW¼ of sec. 14, Greenwood Township, where we had been directed by a nearby farmer in response to our desperate search for a good woodlot in otherwise rather bleak terrain. Here, *C. caroliniana* (3445) was abundant and we included in the collection a narrow-leaved plant bearing 6 stems from a single corm in the midst of a colony of wide-leaved ones. No other plants with narrow leaves were seen, and these were perhaps a little less linear than usual for *C. virginica;* we assumed them to be aberrant *C. caroliniana,* being unaware at the time that the two might grow so close together. But they have since been confirmed as *C. virginica* by R. J. Davis. This woods should be examined again more thoroughly.

Somewhat farther south in Clare County, along Highway M-115 ca. 4 mi. NW of Farwell, chiefly in the NE¼ of sec. 17, Surrey Township, is a beech-maple woods in which Richard C. Crickmer and I found both species on May 12, 1961. Oddly enough, only *C. virginica* (9711) was on the north side of the highway and only *C. caroliniana* (9707) on the south side. If once they grew beside each other, the highway must have destroyed the area of overlap. The plants of *C. caroliniana* were more advanced, even starting to turn yellow while those of *C. virginica* were yet green.

MUSKEGON COUNTY: While both species have not been found together, despite search in many woods in the northwest part of the county, there remains the possibility of a mixed site in Muskegon County. On May 14, 1960, T. R. Detwyler and I found large plants of *C. virginica* common in a low maple woods in the NE¼ of sec. 13, White River Township, ca. 2½ mi. NW of Montague—well within its range. While both species of *Erythronium, E. albidum* and *E. americanum,* were in this woods, we did not find the other *Claytonia.* Not until May 3, 1964, did *C. caroliniana* turn up as far south as Muskegon Co., when R. L. Stuckey, C. W. Laskowski, and I found it in deciduous woods in the NE¼ of sec. 12 (11470) and the E½ of sec. 11 (11472), White River Tp.—both stations only about a mile from *C. caroliniana*—and near the E edge of sec. 1, about 1½ mi. north (11464).

OCEANA COUNTY: On May 15, 1957, about 6:30 p.m., James S. Wilson and I decided to delay our search for a campsite long enough for a quick look into a beech-maple woods about 2½ miles west of Shelby. On the north side of a ravine we found *C. virginica* (3747), mostly with a few flowers left; on the south side, *C. caroliniana* (3745), mostly just past flowering; and along the bottom of the ravine an assortment of plants (3746) which at the time we thought might include some hybrids. (Later segregation into the two species was made by R. J. Davis.) This woods was the first recognized station in Michigan for the occurrence of both species, and on May 3, 1964, a return visit, with R. L. Stuckey and C. W. Laskowski, was made at a more favorable time of day. The meeting point of the two species is the second east-west ravine south of the county road (and paralleling it). The ravine expands westward into the wide valley of Stony Creek, which flows from north to south. On the west-facing slope of the upland, facing the valley of Stony Creek, there is *C. caroliniana,* which is also on the south or north-facing, slope of the ravine and the upland thence southward. On the north, or south-facing, slope of the ravine and thence northward is only *C. virginica.* Both species occur at the bottom of the ravine. Plants bearing leaves which appeared to include shapes of both species in one compact group of stems (Fig. 6) were painstakingly excavated, revealing two corms of *C. virginica* (11455) and one corm of *C. caroliniana* (11456) nearly or quite touching each other. It was here that we realized that a phenological difference exists when the two species do grow under identical conditions. Young buds were very scarce on *C. caroliniana* while they were common on *C. virginica.*

Fig. 7. *Claytonia virginica* and *C. caroliniana* (note pair of broad leaves in lower center, behind peduncle and large linear leaves of *C. virginica*), growing together on Round Island, Mackinac Co., Michigan, May 29, 1967.

If hybridization does occur between the two species, it may be taking place in this ravine. Certain plants (e. g., 11459 and some of 3746) are of ambiguous leaf shape when considered by themselves, but would not be too far out of line for either species (especially *C. virginica*) if found in otherwise pure stands. None of them have been annotated as possible hybrids by Davis, but in the light of Uttal's Virginia report (1964) I think further study is warranted.

ROUND ISLAND (MACKINAC CO.): In the herbarium of the Cranbrook Institute of Science is a sheet bearing two specimens labeled as *C. virginica,* collected on "hardwood plateau" of Round Island, in the Straits of Mackinac, between Mackinac Island and Bois Blanc Island, in June of 1941 by Marjorie T. Bingham. In 1957, I felt that these must be aberrant individuals of *C. caroliniana,* especially since the lowest bract was scarious as sometimes stated for that species in manuals. The site seemed far out of range for *C. virginica* (which was unknown from the neighboring mainland in any direction) although the leaves were quite linear (all at least 15 times as long as broad). Only a visit to Round Island[9] could climax my decade of *Claytonia*-hunting, and on May 29, 1967, the opportunity came, through the kindness of John W. Childs, of Wayne State University, and his wife.

The high interior of the island, above the strong shoreline of post-glacial Lake Nipissing and the thickets below it, rises a hundred feet above the Straits—twice the estimate of Potzger,[9] and is heavily wooded with beech (*Fagus grandifolia*), birch (*Betula papyrifera*), and sugar maple (*Acer saccharum*), the latter in an almost pure stand northward. The trees are mostly only of medium size and the whole upland has rather a park-like aspect. Shrubs such as red-berried elder (*Sambucus pubens*) are heavily browsed. On the calm, sunny day when we were there, the forest floor was carpeted with a wide assortment of spring wildflowers, the most abundant being *Claytonia caroliniana*—which was apparently responsible for the fragrance which perfumed the air. It seemed surprising that Mrs. Bingham had not collected this species when she was on the island, but perhaps in June she was too late, and could find only the slightly later *C. virginica* in suitable condition to collect. For toward the north end of the upland, we did find *C. virginica* (12440), thoroughly intermixed with *C. caroliniana* (12439) and, as usual, less far advanced (Fig. 7). The plants first drew our attention by their white flowers and large size. Subsequently, some pale pink-flowered *C. virginica* and some white-flowered *C. caroliniana* were also found. One colony of very robust plants (12438) included individuals resembling *C. virginica* f. *robusta* of farther south; they had narrowly elliptical leaves up to 17 x 117 mm, though more typically 8 x 150 to 9 x 160 mm. Although *C. caroliniana* was abundant throughout the upland of Round Island, we found *C. virginica* with it only in a very limited area near the north side. In considerable spring collecting on the mainland to the south, in Emmet and Cheboygan counties around the University of Michigan Biological Station, *C. virginica* has never been found; the nearest known location is almost 100 miles south of Round Island, in Alcona County.

[9]The island, scarcely 1½ miles long and in federal ownership, is now completely uninhabited, the lighthouse at its north end (across from Mackinac Island) having been abandoned since the brief botanical report, based on two days of August collecting, by J. E. Potzger: The Vegetation of Round Island (Straits of Mackinac), Michigan. Butler Univ. Bot. Stud. 6: 116-122. 1944. The Round Island Quadrangle (7½', U. S. Geol. Surv., 1964) provides an up-to-date map of the island.

IN CONCLUSION

The collections of the past 11 seasons have shown that the ranges of our two species of *Claytonia* do meet, indeed overlap, across the middle of the state; that both species, neither one clearly more so than the other, are extremely variable morphologically and in flower color, which ranges from white to deep pink; that leaf *shape* seems to be the only consistent distinguishing character—and even this is occasionally ambiguous; and that when both species grow together, *C. virginica* reaches the peak of its flowering later by perhaps a few days—no longer—than *C. caroliniana.*

This report documents in some detail the distributions of the two species in Michigan, with special reference to the area of overlap and to unusual occurrences, with some additional data from Ontario and neighboring states. I hope that, as a result of these data, botanists in the region will become interested in pursuing the important as yet unanswered questions: Why are the ranges what they are? Given that climatic or historical factors may explain the general ranges of the species, then why in the zone of overlap does one woods usually have only one of them while a nearby woods has only the other? Do the two species in fact hybridize? What normally prevents hybridization when the two grow together? What is the range of cytological diversity which they exhibit and is it correlated in any way with the geographical range or with morphological variability? Are there some unrecognized but better or more consistent characters than leaf shape to distinguish the species and to identify hybrids?

Research on the "Claytonia problem" is barely begun in the local flora, even though we know very much more about the occurrence of the species than we did 12 years ago!

ACKNOWLEDGMENTS

I am grateful to many persons who have aided the search for knowledge about spring beauties during the course of this work: to the late Dr. Lulu O. Gaiser of Crediton, Ontario, who wrote me of the Thedford woods and lent specimens from Lambton County, some of which were retained for the University of Michigan Herbarium and the others returned after Dr. Gaiser's death to Raymond J. Moore to be included with her collections left to him and placed in the herbarium of the Canada Department of Agriculture, Ottawa (DAO); to Dr. Ray J. Davis of Idaho State University who kindly examined over 200 collections of *Claytonia* from the University of Michigan Herbarium late in 1964; to the numerous residents of Michigan who have granted me permission to explore their woodlots (and to those from whom, because of circumstances, permission could not be sought); to the many students, botanical colleagues, and other friends, some of them previously mentioned, who joined in the search; to those who have provided photographs to illustrate this report; and to the curators of herbaria where specimens were examined: Michigan State University (MSC), Cranbrook Institute of Science (BLH), Wayne State University (WUD), Isle Royale National Park (IRP); and the University of Michigan Biological Station (UMBS). The distribution maps are based on specimens in these herbaria, in addition to the University of Michigan Herbarium (MICH) and my personal herbarium (at Mackinaw City). Specimen collection numbers have been cited whenever it seemed advisable to be specific, for the benefit of any who may want to examine particularly interesting records. Except when otherwise indicated, all cited numbers are mine and all collections are in the University of Michigan Herbarium (with occasional duplicates distributed elsewhere).

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NEW LOCALITIES FOR MOSSES RARELY FOUND IN MICHIGAN'S UPPER PENINSULA

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As a result of field studies during the course in Algae and Bryophytes taught at the Northern Michigan University Field Station and personal research, I have found new localities for mosses rarely collected in the Upper Peninsula of Michigan. These mosses are *Mnium andrewsianum* Steere, *Mnium pseudopunctatum* Br. and Sch., and *Schistostega pennata* Hook. and Tayl. Each of these is reported from but one Michigan locality in Darlington (1964).

Mnium andrewsianum Steere as first reported by Mazzer and Sharp (1963) was new to the United States and they described its locality as a bog along the Melstrand Road about eight miles east of Munising, Alger County. My collection was made in a swamp near Ross Lake, Schoolcraft County.

Mnium pseudopunctatum Br. and Sch. was collected for the second time in the Upper Peninsula during a visit to the Grand Sable Dunes along Lake Superior west of Grand Marais, Alger County. Another collection was made in a bog of

Calla palustris L., Wild Calla, along the Dead River at the north edge of Marquette, Marquette County. The previous records for this species in Michigan are: Lowry (1948), Lake City, Missaukee County; Darlington (1964), Cecil Bay, Emmet County (Sharp); and for the Upper Peninsula, Crum (1964), Mackinac Island, Mackinac County (Wynne).

Schistostega pennata Hook. and Tayl. was first discovered in Michigan by Nichols (1933) in the cave behind Scott Falls approximately ten miles west of Munising, Alger County. Geologically, this is just into the limestone area of the eastern half of the Upper Peninsula. Knowing that similar caves exist in limestone cliffs along Lake Superior, I looked for this moss and subsequently found it in the caves along Powell Point approximately two miles west of Munising.

While none of the above collections add significantly to the range of the mosses, they do give more complete knowledge as to their distribution pattern in Michigan. The voucher specimens for these new records are in the herbarium of M. C. Bowers.

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MICHIGAN PLANTS IN PRINT

New Literature Relating to Michigan Botany

B. BOOKS, BULLETINS, SEPARATE PUBLICATIONS

Barneby, Rupert C. 1964. Atlas of North American Astragalus. Mem. N.Y. Bot. Gard. 13. 1188 pp. in 2 vols. $35.00. [Distribution maps in this monograph include 3 Michigan stations for *A. canadensis* var. *canadensis* and 9 for *A. neglectus,* the latter also including a Farwell name, based on Lapeer County specimens, in synonymy.]

Dansereau, Pierre, & Gérard Pageau. 1966. Distribution Géographique et Écologique du Betula alleghaniensis. Mem. Jard. Bot. Montréal 58. 56 pp. [Distribution map unique in employing different symbols for different habitats where yellow birch occurs; a number of Michigan stations included. A peripheral station in Michigan is said to be Moran in "Tahquamenon" county (there is no such county; Moran is in Mackinac Co.). Phytosociological data from 35 stations, including 3 in Michigan: Tahquamenon Falls, Wolf's Bog in Cheboygan Co., and Highland "State Park" (i. e., State Recreation Area–which is in Oakland Co., not Wayne as stated).]

Kreisel, Hanns. 1967. Taxonomisch-Pflanzengeographische Monographie der Gattung Bovista. Nova Hedw. Beih. 25. 244 pp. + 70 figs. DM80 or $20.00. [Michigan specimens are cited for several species of these puffballs, and the very generalized distribution maps includes ranges which pass through this region.]

Editorial Notes

Upon the expiration of terms of members of the Editorial Board of THE MICHIGAN BOTANIST, we take this opportunity to express appreciation to the retiring members, Charles Barclay, Dr. C. M. Rogers, and Dr. Warren P. Stoutamire, and to welcome three new members: Dr. Virginia L. Bailey, chairman of the Department of Biological Sciences, Detroit Institute of Technology; Dr. Burton V. Barnes, associate professor of forestry, The University of Michigan; and Dr. Richard Brewer, director of the Charles C. Adams Center for Ecological Studies and associate professor of biology, Western Michigan University, Kalamazoo.

In this issue, we introduce some new type faces—the first such change since the journal began in 1962. Reactions from readers, whether pro or con, will be welcomed. Is the type as readable as before, or more so, or less so?

Good black and white prints of botanical subjects, suitable for use on the cover of THE MICHIGAN BOTANIST, are always welcome and may be submitted to the editor at any time.

The January number (Vol. 7, No. 1) was mailed January 4, 1968.

"Winter Wildflowers"

The Michigan Botanical Club has undertaken a new project to culminate in Special Publication No. 2, on the winter appearance and uses of wild plants. Photographs (no smaller than 5 x 7) of artistic merit, showing in general a single species of wild plant, are needed—those with distinctive and recognizable inflorescences, berries, etc., that might be noticed on a winter hike or used in "winter bouquets." Photographs of a few effective arrangements of dried native materials are also wanted. Especially desired are specific directions from persons who have successfully employed different techniques of preparing wild winter plants for use—such as drying with various agents, spraying to prevent disintegration, embedding, glycerin treating, arranging pictures or greeting cards, and so forth.

Anyone with doubts as to the identification of his material should save a specimen for checking. Credit will, of course, be given to all whose photographs and suggestions are accepted for inclusion by the booklet committee. All materials should be submitted to the committee chairman, Dr. Helen V. Smith, 1766 Glenwood Rd., Ann Arbor, Michigan 48104.

Errata

In addition to a few obvious omissions, alterations, or transpositions of letters, the following recent errata may be noted:

Vol. 6, p. 21, line 23, for "1. 51" read: p. 51
p. 31, line 2 from bottom, for "26 years" read: 27 years
p. 91, line 16, for "173" read: 1753
Vol. 7, p. 28, line 9 from bottom: for "Ecology" read: Am. Midl. Nat.

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(On the cover: Woods at the south edge of Ypsilanti, Washtenaw Co., Michigan, carpeted in the spring with Claytonia virginica, *the narrow-leaved Spring Beauty. Photo by A. H. Smith.)*

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Articles and notes dealing with any phase of botany relating to the Upper Great Lakes Region may be sent to the editor in chief. The attention of authors preparing manuscripts is called to "Information for Authors" (Vol. 6, p. 202; reprints available from the editor).

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THE STATUS AND DISTRIBUTION OF *GENTIANA LINEARIS* AND *G. RUBRICAULIS* IN THE UPPER GREAT LAKES REGION[1]

James S. Pringle
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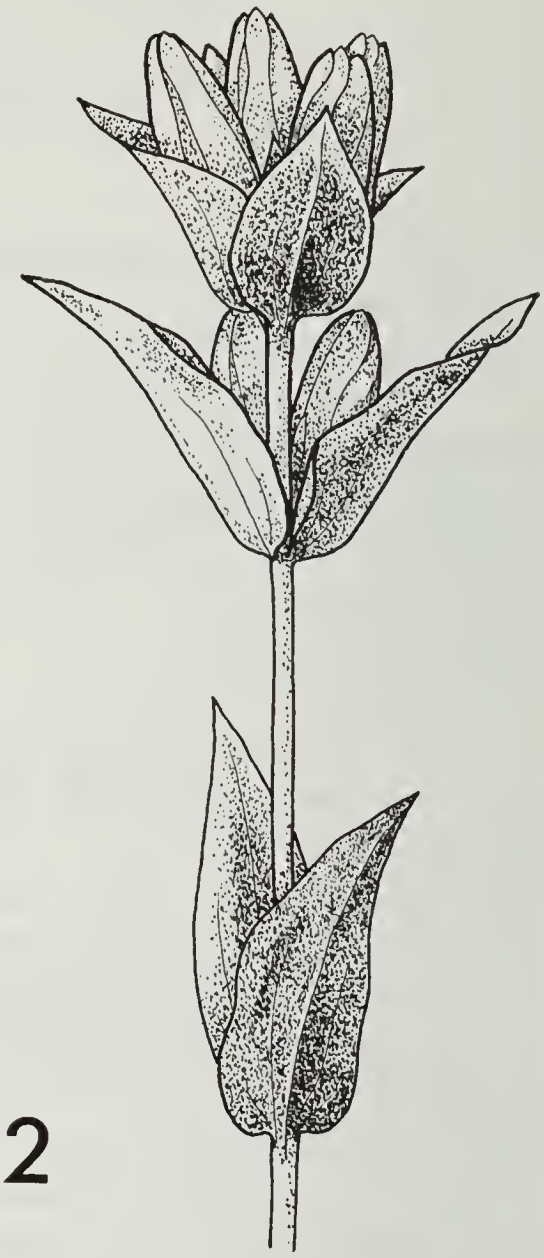
During the preparation of my monograph on *Gentiana,* section Pneumonanthae, in eastern North America (Pringle, 1967a), it became evident that especially interesting problems in plant geography and evolutionary botany were associated with two closely related species, *G. linearis* Froel. (Narrow-leaved or Bog Gentian) and *G. rubricaulis* Schwein. (Red-stemmed Gentian). These are illustrated in Figures 1 and 2; their ranges are shown in Figure 3. Descriptions of these and related species have previously been published (Pringle, 1967a). Details of their distribution have remained obscure, in part because they have often been confused with each other and with several related species, and in part because, until recently, few specimens had been collected from large portions of their ranges. The distinctness of *G. rubricaulis* from *G. linearis* and hence its proper taxonomic status have also remained in question.

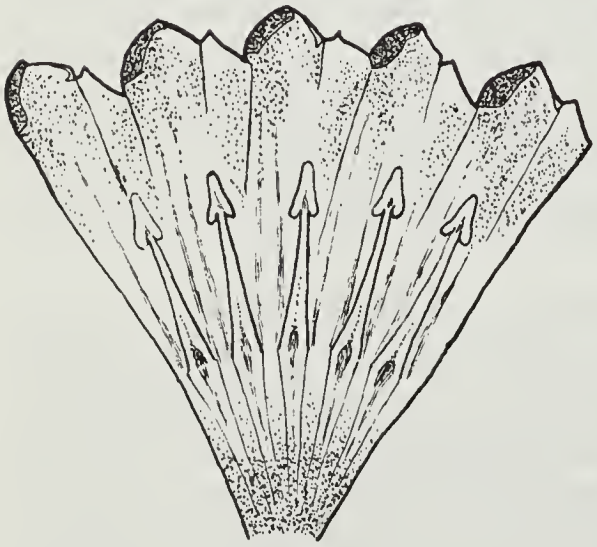
This paper deals with the problems mentioned above, and with the nature of the isolation which permits these species to retain their distinctness. It is intended in part to lay the groundwork for a later paper on the origin, relationships, and migrational history of *G. rubricaulis,* which will report the results of studies currently in progress. The origin of *G. rubricaulis* is a problem of particular interest, because this species is restricted to territory glaciated during the Wisconsin period, with no outlying populations indicating a survivium from which it could have spread as the glaciers receded.

In my studies of *Gentiana,* I have examined the specimens in about eighty herbaria, and have observed and collected plants in the field in many parts of North America. This study of *G. linearis* and *G. rubricaulis* has included field trips to many localities in northern Michigan, including all extensive areas of granitic soils in the Upper Peninsula, as indicated by Martin's maps (1957), to adjacent portions of Wisconsin, and to a number of areas north and east of Lake Huron in Ontario.

As Figure 3 indicates, *G. linearis* is primarily an eastern species. It was apparently first collected in the Lake Superior region by Loring, who encountered it between the Pic River and Sault Ste. Marie in Ontario, probably about the middle of the nineteenth century. It does not appear to have been collected in this region again until 1935, when it was discovered along the Batchawana River in Ontario (*Taylor et al.;* specimens cited below). It was first collected in Michigan in 1942 (*Bingham*). The occurrence of *G. linearis* in the Lake Superior region has remained in question up to the present, since few specimens of it had

[1]Contribution from the Royal Botanical Gardens, Hamilton, Ontario, No. 8, and from the University of Michigan Biological Station.





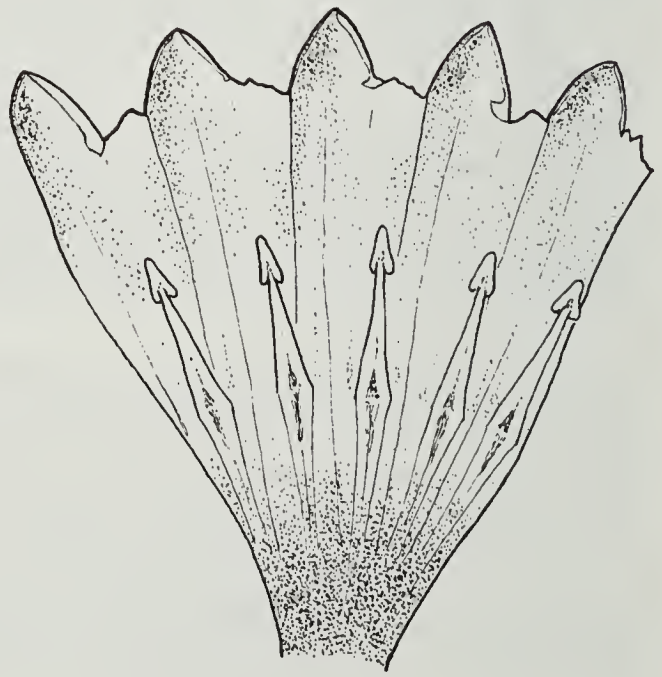


Fig. 1. *Gentiana linearis.* Fig. 2. *G. rubricaulis.* Upper parts of flowering stems, x ½ (above), and corollas slit longitudinally and pressed, with connate anthers separated, x 1 (below).

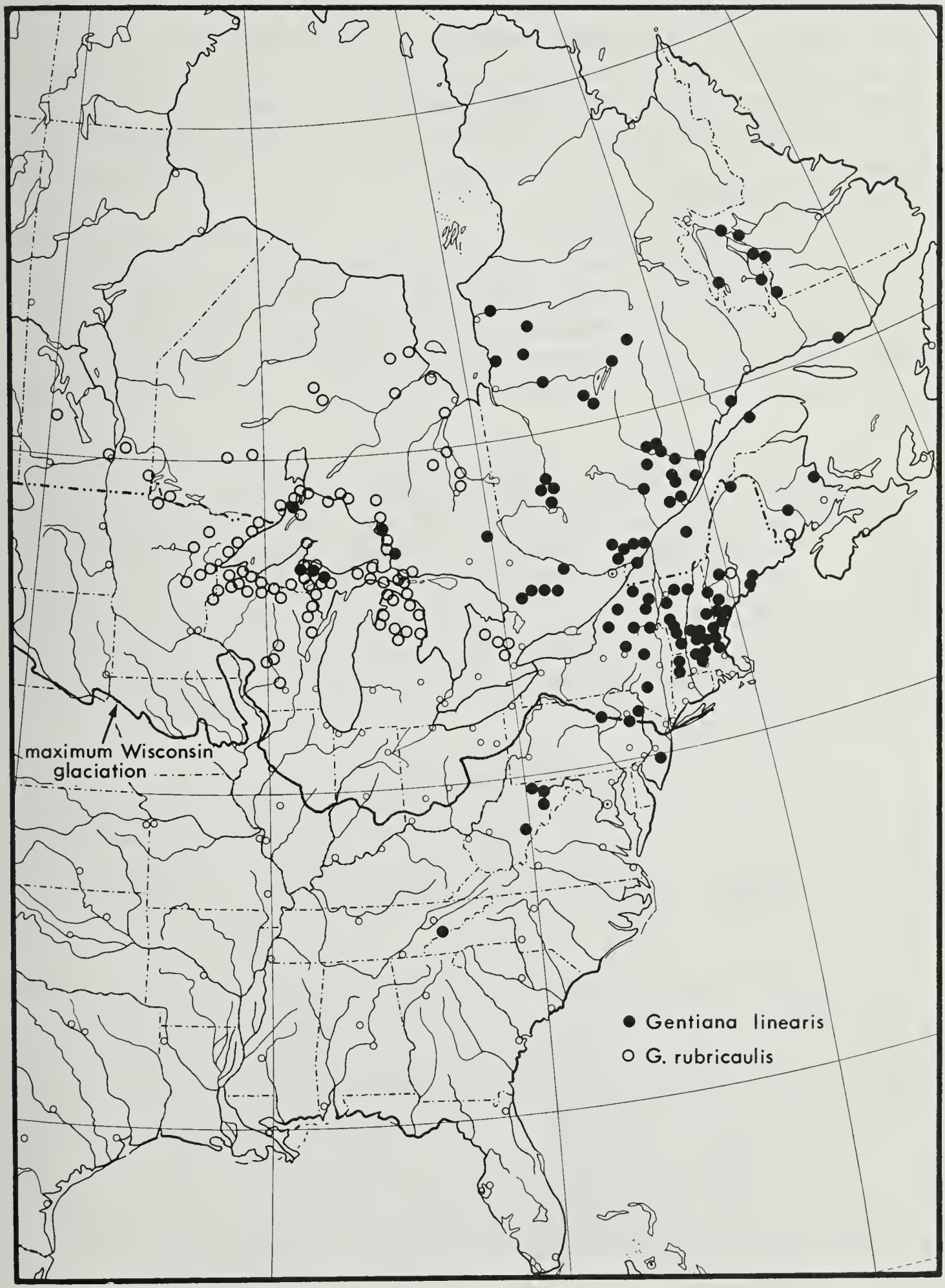


Fig. 3. Distribution of *Gentiana linearis* and *G. rubricaulis*.

been collected in this region until the present study was undertaken, and most of these had been deposited in smaller herbaria. Fernald (1950) included the Lake Superior region in its range;[2] Gleason and Cronquist (1963), however, indicated that its range extended westward only to New York and West Virginia. The westernmost station[3] mapped by Gillett in 1963 was in the eastern part of northern Ontario. The present paper documents the occurrence of *G. linearis* in the Lake Superior region, and includes the results of a study of the extent of its occurrence in this region, the size and vigor of its populations, and the ecologic basis of its restricted distribution.

The following list includes all the specimens of *G. linearis* I have encountered which were collected west of Sault Ste. Marie. Specimens of other species, and of *G. linearis* from other regions, have previously been listed (Pringle, 1967b). Abbreviations for herbaria follow Index Herbariorum, ed. 5, with the additions of FORD, for the herbarium of the Ford Forestry Center, Michigan Technological University, and HMC, for the herbarium of the Huron Mountain Club.

MICHIGAN: BARAGA CO.: Haypress Dam meadow, T50N R30W, *Bourdo* 15 Aug 1961 (FORD, MSC, UWM); along Huron Bay–Peshekee Road, center of Sec. 26, T50N R31W, *Pringle 808* (HAM, MICH). MARQUETTE CO.: shore, Ives Lake, *Bingham* July 1942 (BLH); Yellow Dog Plain, in former river bed, T50N R28W, *Hyypio 292* (MSC, TEX); about small, drying lake in Yellow Dog Plain, Sec. 9, T50N R29W, *Stoutamire 3129* (BLH, HMC); along Marquette Co. Road 607, 1.0 mi s of jct with road to Lake Arfelin public access, Sec. 27, T49N R30W, *Pringle 399* (DAO, HAM, MICH); by road to Lake Arfelin public access nr crossing of Ephraim Creek, *Pringle 389* (HAM, MICH); s shore Ives Lake, *Pringle & Harris 400* (HAM, HMC, MICH); just n of Swanzy Lake, Old Swanzy, *Pringle 426* (DAO, HAM, MICH); shore of Harvey Lake, Sec. 31, T47N R25W, *Pringle 837* (ACAD, DAO, HAM, MICH, OS, WUD).

ONTARIO: ALGOMA or THUNDER BAY DIST.: Pic to Sault, *Loring* no date (GH). ALGOMA DIST.: Batchawana Falls, *Taylor et al. 1335* (CAN, DAO, MT, TRT, US); Batchawana River, *Taylor et al. 1336* (WASH), *1338* (GH); w shore of small lake situated between Otter Lake and Hwy. 17, Lake Superior Provincial Park, *Cowell 281* (TRT); drained beaver lake beside old logging road, Lost Lake, Lake Superior Provincial Park, *Cowell 301* (TRT). THUNDER BAY DIST.: Thunder Cape, Sibley Peninsula, w side at lake level, *Löve & Löve 6953a* (WIN).

G. linearis is highly localized in Michigan and northwestern Ontario. Within some limited areas, however, it is quite abundant, and forms sizeable populations. It is, for example, a common species in the highlands of Marquette and Baraga Counties northwest of Champion, Michigan, where it not only occurs in relatively stable communities but also soon colonizes newly available sites. In such areas *G. linearis* is obviously a well-established component of the native flora. Its restricted distribution in the Upper Great Lakes region does not appear to be due to recent arrival, nor does the species appear to be a relict which is being eliminated by changing conditions. Instead, it appears that a limitation of

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[2]And also Minnesota; Minnesota reports, however, appear in all cases to have been based on misidentifications or failure to distinguish between *G. linearis* and *G. rubricaulis.*

[3]Of *G. linearis sensu stricto*–Gillett's *G. linearis* ssp. *linearis.*

suitable habitat is largely responsible for its restricted distribution. The probable nature of this limitation is discussed later.

Some botanists have assumed that *G. linearis* and *G. rubricaulis* intergrade in the Great Lakes region [although Fernald (1935) called *G. rubricaulis* "one of the most distinct of species"]. Among the objectives of my study has been to determine to what extent, if any, these species do intergrade, and what kind of isolation permits them to retain their distinctness. Breeding experiments indicate that hybridization between *G. linearis* and *G. rubricaulis* is genetically possible. It remains to be seen whether such hybrids will be fertile; however, their fertility may reasonably be predicted in view of the similarity of the chromosomes of *G. linearis* and *G. rubricaulis* (Rork, 1949; Pringle, in press) and the general interfertility among species in this group. There appear to be no seasonal or mechanical barriers to their hybridization in nature. Their blooming seasons overlap where they are geographically sympatric, and both species are pollinated by bumblebees. (Plants of these species are self-fertile, but pollination depends on an outside agent.) The anthers and stigmas of the two species are similar in position.

Despite the absence of intrinsic isolating mechanisms, *G. linearis* and *G. rubricaulis* appear hardly ever to interbreed in nature. Two specimens from Marquette County, Michigan, one from Ives Lake and one from Gwinn, have previously been cited as possibly being of hybrid origin (Pringle, 1967a). The Ives Lake specimen [*Bingham* July 1942 (BLH)] was collected in an area notable for its diversity of habitats (Hagenah, 1963). Both *G. linearis* and *G. rubricaulis* have been collected at nearby localities. In general the specimen is characteristic of *G. linearis*, but its involucral leaves are wider toward the base than is usual in this species, and they appear to have enveloped the calyces somewhat. These traits suggest possible introgression of genetic material from *G. rubricaulis*. In 1965, however, the small population at Ives Lake consisted only of entirely characteristic *G. linearis*, with narrow, spreading involucral leaves [*Pringle and Harris 400* (HAM, HMC, MICH)].

A specimen collected 16 Aug 1908 by Harrison and Harrison "in shade along Halfway Creek northeast of township road, Gwinn" (GH)[4] seems very likely to be a hybrid between *G. linearis* and *G. rubricaulis*. This specimen consists of two stems bearing marcescent corollas and ripe fruits. The leaves, like those of *G. linearis*, increase only slightly in length and width toward the summits of the stems, and appear to have been similar to leaves of *G. linearis* in texture and color. The involucral leaves, although no wider than the involucral leaves of occasional plants of *G. linearis*, are widest toward their bases, and they evidently enveloped to a degree the bases of the inflorescences, as do the leaves of *G. rubricaulis*. The calyx lobes are similar in size and shape to those of *G. rubricaulis*. The corolla lobes are as long as those of *G. rubricaulis*, but are strongly cucullate toward the outer edge, like those of *G. linearis*. This specimen is like *G. linearis* in having had ripe fruits as early as August 16, and the seeds, in

[4]In previous papers (Pringle 1967a, b) I erroneously cited the Harrisons' 7 Aug 1908 collection from Tamarack Street, Gwinn (GH) as the possible hybrid. Specimens in this collection are entirely characteristic of *G. rubricaulis*, as were all the plants in the Tamarack Street population in 1965 [*Pringle 394* (HAM, MICH)].

being relatively short and elliptic rather than oblong, are like those of *G. linearis.* This specimen was probably collected along the creek just northeast of its crossing by what is now Highway M-35. Considerable building and recreational use of the remaining open land have taken place along this part of Halfway Creek since 1908. In searches along this portion of the creek in 1965, and along relatively undisturbed stretches further upstream in 1967, I was unable to find any gentians. Evidently no extensive population of intermediates has become established.

Gillett (1963) viewed *G. linearis* and *G. rubricaulis* (as *G. linearis* ssp. *linearis* and ssp. *rubricaulis*) as two subspecies with contiguous, rather than overlapping, ranges. Specimens from the vicinity of Sudbury, Ontario, were said to be intermediate, indicating intergradation where the ranges met. For this reason he considered the two taxa best recognized as two subspecies of a single species. From correspondence with Dr. Gillett, and from searches of the herbaria he used, it seems most likely that the specimens involved are *Watson 1909* and *1914* (TRT), from Timagami Provincial Forest, Nipissing District. The leaves and calyx lobes of these specimens are proportionately wider than is common in *G. linearis* and are narrowly elliptic rather than strictly linear. Otherwise these specimens appear typical of *G. linearis.* Such leaves occur occasionally throughout the range of *G. linearis,* especially on plants in shaded sites. These specimens should probably be interpreted as representative of variation within *G. linearis s. str.,* rather than indicative of intergradation with *G. rubricaulis.*

I have found no other specimens at all intermediate between *G. linearis* and *G. rubricaulis.* Moreover, *G. linearis* in its outlying populations in the Lake Superior region does not appear to differ in any morphologic aspect from the species in other parts of its range. Evidently, therefore, the situation is neither one of clinal intergradation from *G. linearis* extremes in the East to *G. rubricaulis* extremes in the Upper Great Lakes region nor one of extensive hybridization.

Even if the few specimens cited above do indicate that hybridization between *G. linearis* and *G. rubricaulis* has occurred, this hybridization would scarcely constitute by itself an adequate basis for classifying these two taxa as a single species. There is a remarkable amount of interfertility within *Gentiana,* and hybridization is not uncommon, even among highly diverse species. (See Figure 7 and Pringle 1965, 1966, 1967a.) Indeed, considering how frequently some *Gentiana* species hybridize, the distinctness between *G. linearis* and *G. rubricaulis* seems especially sharp.

The morphologic differences between *G. linearis* and *G. rubricaulis* appear to be comparable to those among other generally recognized species of *Gentiana* in North America. The descriptions of the eastern North American species of *Gentiana,* section *Pneumonanthae,* in my recent monograph (Pringle, 1967a) provided a convenient basis for an objective approach to this matter. The thirteen species descriptions in this paper closely parallel one another in format, and were designed to deal with all of the readily discernible traits of gross morphology in which any of these species differ from any others. Based on observations of several thousand specimens, these descriptions indicate the para-

meters of variation in about forty traits of presence or absence, size, shape, color, puberulence, and coherence of floral and vegetative organs. Dissimilarity values indicating the extent of the differences between any two species were obtained by comparing the two species trait by trait, following the monograph descriptions. Values were derived by adding points as follows: 0, if there was no appreciable difference in the trait being considered; 1, if there was a slight to moderate difference in the extremes reached, but considerable overlapping of the range of variation; 2, if there was a greater difference in the extremes but still considerable overlapping; 3, if the extremes and means were distinctly different but overlapping could still be found; 4, if there were moderate differences, with no overlapping in the ranges of variation; and 5, for extreme differences. A value of 53 was obtained in contrasting *G. linearis* with *G. rubricaulis.* Values for other comparisons of closely related species include: *G. clausa* - *G. andrewsii* (exclusive of forms derived through introgression), 35; *G. saponaria* - *G. catesbaei,* 37; *G. alba* - *G. villosa,* 57; *G. clausa* - *G. saponaria,* 60. Comparing less closely related species produced divergence values of 70 for *G. autumnalis* - *G. puberulenta,* 97 for *G. autumnalis* - *G. villosa,* and 114 for *G. autumnalis* - *G. andrewsii.* In contrast, a comparison of the two varieties of *G. andrewsii* resulted in a dissimilarity value of only 10. In summary, then, both the sharpness of the distinction between *G. linearis* and *G. rubricaulis* and the extent of the differences between them appear to justify their recognition as two species, following the treatments in the commonly used manuals for northeastern North America.

As Mayr (1942) and Levin (1967) have pointed out, a clinal gradient may be expected between races which have differentiated gradually, without a history of complete separation. In contrast, sympatric, closely related entities would be expected to remain relatively distinct if they had spread from different centers; just how distinct would depend on how different were the ecologic conditions to which they had become adapted while they were isolated geographically. Sharp delimitation from related taxa may also be expected of species which have arisen abruptly, as through interspecific hybridization, if they have been isolated genetically (as with allopolyploid hybrid derivatives) or otherwise from related species since their origin. The sharp distinction between *G. linearis* and *G. rubricaulis* is contrary to what one would expect if the latter were merely an ecotype which had differentiated gradually as *G. linearis* spread westward. From a phylogenetic viewpoint of plant classification, the recognition of *G. rubricaulis* as a species may be further supported if current studies indicate that the origin and development of *G. rubricaulis* were distinct from the history of *G. linearis.*

Since the isolation of *G. linearis* from *G. rubricaulis* in the Upper Great Lakes region seems to be due primarily to extrinsic factors, their ecologic positions have been compared. Figure 4 shows a typical *G. linearis* habitat along Ephraim Creek, northwest of Champion, Michigan. This is an open, wet valley among rocky hills which are vegetated largely by white spruce [*Picea glauca* (Moench) A. Voss]. The gentians occur in a community dominated by grasses and sedges, above the level of standing water, below the spruces. Other habitats include moist places along road cuts in this area. In the sandy outwash plains to

the southeast, the gentians occur around kettles, again among grasses and sedges in a fringe between the flooded communities below and the dry hills above. In all cases, the sites are open or partially shaded, constantly moist but never inundated.

G. linearis is most abundant in the Appalachians and in the highlands of the northeastern states and Québec. In these regions the soils are predominantly strongly acid, and have developed from granite, gneiss, and similar crystalline rocks with very low base contents. West of the Appalachians, granitic soils are far less common, and are largely restricted to northern latitudes, where rocks of the Canadian Shield are near the surface. South of Lake Superior, *G. linearis* occurs only in northwestern Michigan, where outlying portions of the Canadian Shield are located. From Figure 5, which shows the distribution of *G. linearis* in northwestern Michigan in relation to geologic factors, it is evident that *G. linearis* in this region is closely associated with granitic soils. It occurs in areas of lithosols and ground till derived from underlying granite; moraines which, from their positions in relation to areas of granitic rock and directions of glacial movement, may be assumed to be largely granitic in content; and outwash plains directly "downstream" from such granitic moraines.

Like *G. linearis, G. rubricaulis* grows in open or partially shaded sites which are consistently moist but not inundated. Probably its most frequent habitats are grass-sedge meadows along the sandy shores of large lakes. It also

Fig. 4. Habitat of *Gentiana linearis* along Ephraim Creek, northwest of Champion, Marquette County, Michigan.

occurs in moist meadows and thickets along streams, and occasionally, especially in northwestern Michigan and Wisconsin, where it is most abundant, in swamps and bogs and around kettles in outwash plains. *G. rubricaulis* grows in both alkaline and moderately acid soils, but not ordinarily in soils of granitic origin. In the area mapped in Figure 5, *G. rubricaulis* is associated with moraines derived from the largely non-granitic Huronian rocks, with outwash from such moraines, and with sandy lacustrine deposits of mixed, often highly calcareous, content.

North of the Great Lakes region, *G. linearis* likewise appears to be closely associated with granitic areas, while *G. rubricaulis* is associated with non-granitic areas (Figure 6). *G. linearis* occurs only in the eastern part of this region, where soils of granitic origin are predominant. *G. rubricaulis* occurs in the central and western parts. Although the bedrock in the region between the Upper Great Lakes and the James Bay Lowlands is the prevailingly granitic Canadian Shield, there are many areas, some of them extensive, with non-granitic soils. North of Lake Huron there is the extensive Clay Belt, a region of deep lacustrine deposits in the bed of glacial Lake Barlow-Ojibway. The origin of these sediments, at least in the western and central parts of the Clay Belt, was primarily the calcareous rocks of the James Bay Lowlands. Another large lake bed is that of glacial Lake Agassiz, north and west of the Lake of the Woods, also with largely non-granitic sediments. The granite of the Canadian Shield has been abundantly disrupted west of the Clay Belt and the James Bay lowlands by basic intrusives, so that even in areas of lithosols non-granitic soils may prevail locally. Dutilly et al. (1954) have observed that in areas in the upper reaches of the Albany and Attawapiskat watersheds where they collected *G. rubricaulis,* the presence of such species as *Thuja occidentalis* L. and *Ribes hudsonianum* Michx. indicated that the soils were not strongly acid.

The distributional data discussed above indicate that *G. linearis* and *G. rubricaulis* probably remain as sharply distinct as they do where they are geographically sympatric primarily because they grow in localities which differ in soil types. The effectiveness of adaptations to contrasting soil types as an isolating mechanism has been amply demonstrated (Mayr, 1947; Muller, 1952; Riley, 1952).

These gentians are restricted not only to certain conditions of soil chemistry but also to certain conditions of moisture supply, drainage, and openness. Consequently, populations of these species, especially *G. rubricaulis,* are generally small and widely separated. This discontinuity of distribution doubtless enhances the effect of ecologic isolation. The effectiveness of distances of as little as a few hundred feet as barriers to gene flow between populations of insect-pollinated plant species has been demonstrated by Cook (1962). Keener (1966) has provided an example, from the Appalachian shale barrens, of sympatric, interfertile species of *Clematis* which appear to have remained sharply distinct almost entirely because they occur in small, scattered populations. Because of the similarly discontinuous distribution of *G. linearis* and *G. rubricaulis,* the effects of a successful hybridization between them would probably remain confined to the population in which it occurred, paralleling the situation among species of *Phlox* observed by Levin (1967, p. 106).

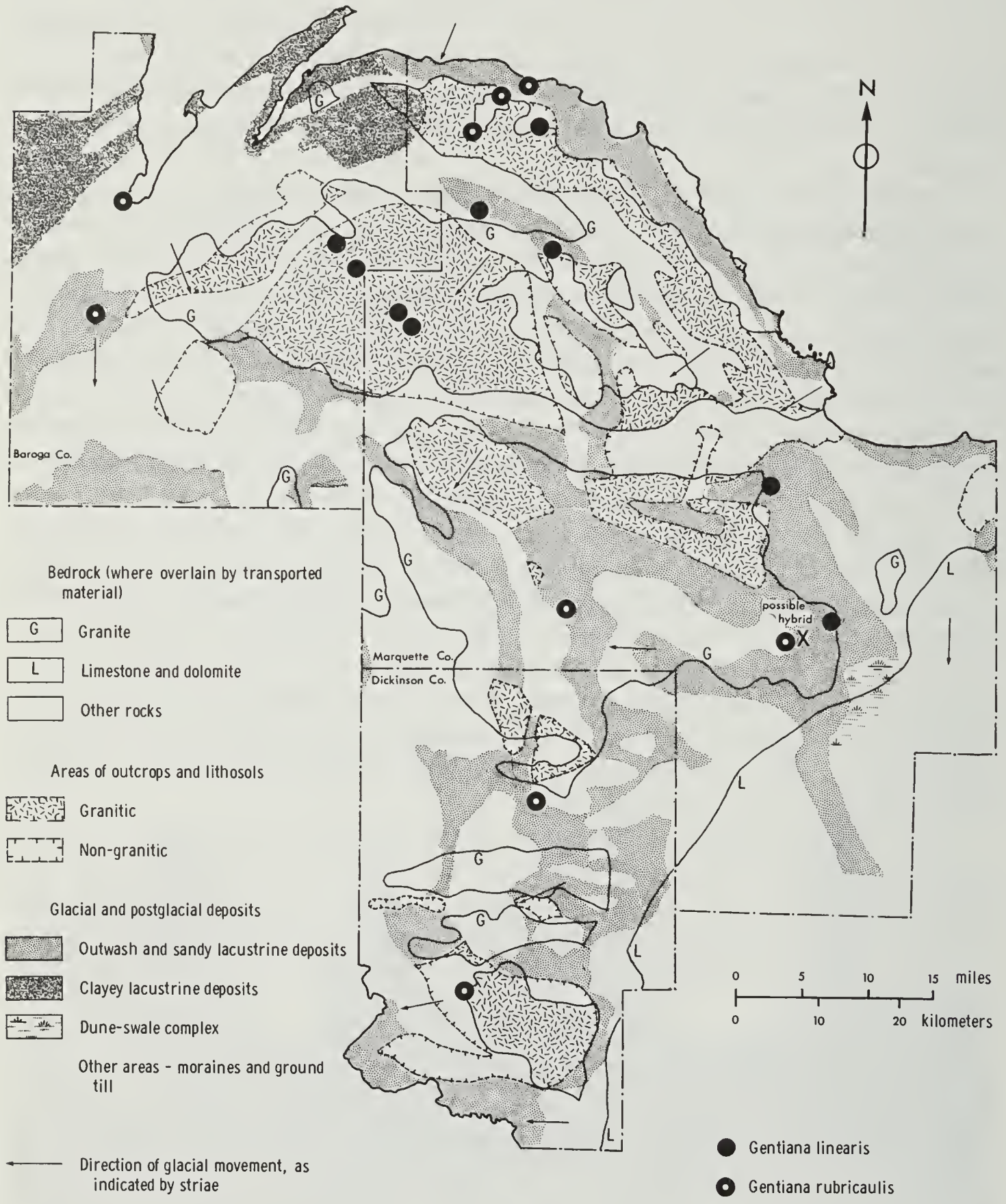

Fig. 5. Distribution of *Gentiana linearis* and *G. rubricaulis* in three counties in northern Michigan, in relation to geologic factors. Geology from Martin (1957).

The distribution of *G. linearis* is paralleled to various degrees by those of certain other species which are relatively common in the Appalachians, the Laurentides, the Madawaska Highlands of eastern Ontario, and other parts of northeastern North America, and also occur sporadically westward to the Lake Superior region. Among these species are *Potamogeton confervoides* Reichenb., *Oxalis montana* Raf., and *Aster nemoralis* Ait. From field observations, habitat notes in manuals, and correlations of the distribution patterns of these species with geologic information, it appears that at least in some cases the rarity of these species westward may be due largely to their being restricted to granitic or strongly acid soils.

There are also a number of pairs of closely related species or varieties with ranges overlapping in the Great Lakes region, of which one member is associated with granitic or acid soils, while the other is found in calcareous soils. In some cases, distribution patterns indicate that the oxylophyte has spread into the

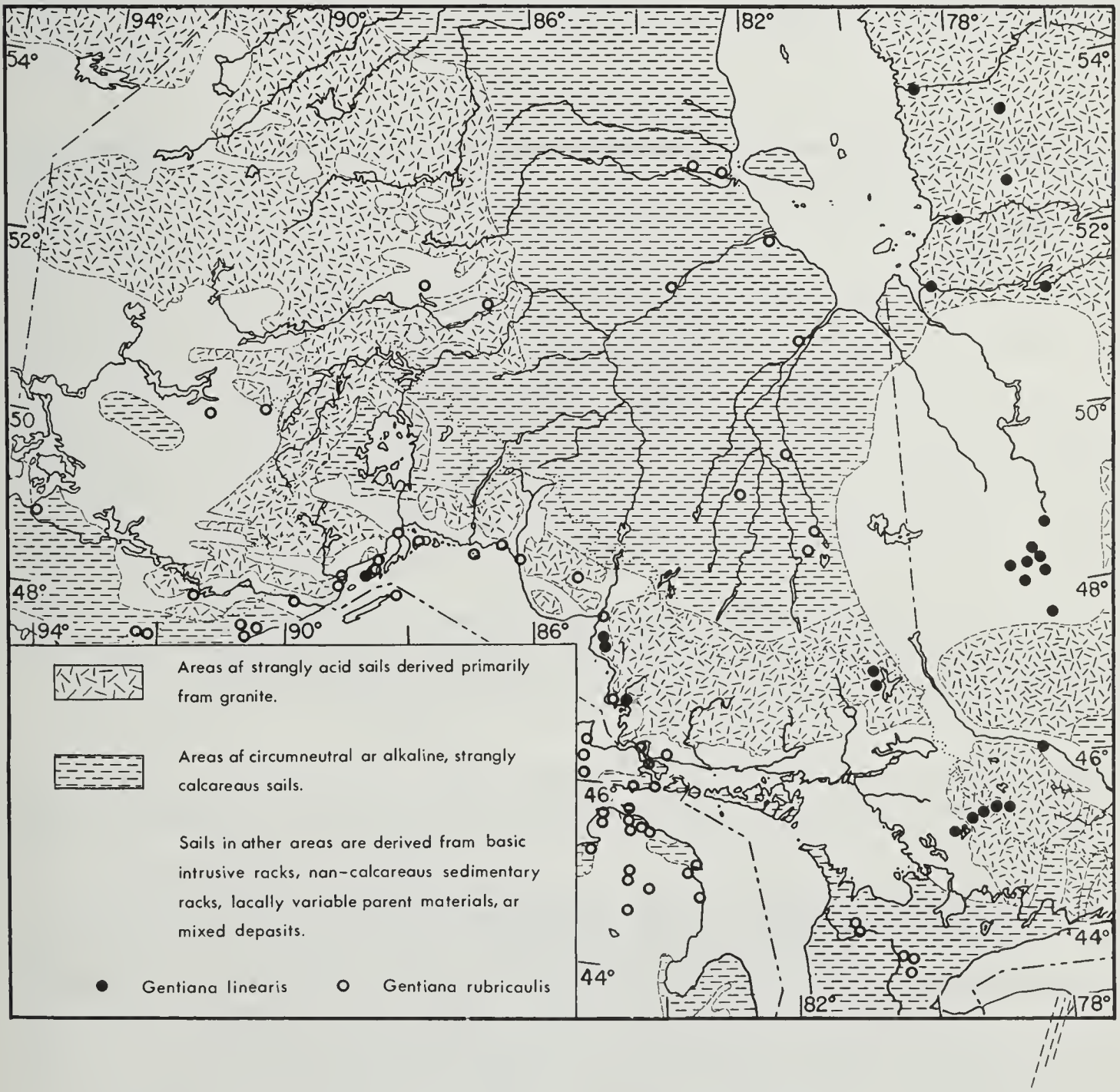

Fig. 6. Distribution of *Gentiana linearis* and *G. rubricaulis* north of the Great Lakes, in relation to geologic and soil factors. Information on geology and soils largely from Hills (1960, 1962), Hills and Morwick (1944), and the Atlas of Canada (1958).

Great Lakes region from the largely granitic Appalachians, while the calciphyte has spread from a non-granitic trans-Appalachian survivium (cf. Iltis, 1965, pp. 149-151). Interfertility between the two members of a pair is known in some of these cases, and may reasonably be expected in others. Therefore, it seems probable that the ecologic isolation which appears to be largely responsible for the distinctness of *G. linearis* and *G. rubricaulis* has a number of parallels. One such parallel has become evident through my studies of *Gentiana. G. clausa* Raf. and *G. andrewsii* Griseb., two similar but distinct species with ranges which overlap from Vermont to Ohio, also appear to be isolated from each other by adaptations to granitic and nongranitic soils, respectively. Other such pairs include *Lilium canadense* L. and *L. michiganense* Farw. [*L. canadense* ssp. *michiganense* (Farw.) Boivin & Cody] ; *Viola blanda* Willd. and *V. incognita* Brainerd; and *Prunus pumila* L. var. *cuneata* (Raf.) Bailey [*P. susquehanae* Willd.] and var. *pumila*. Detailed studies of the distribution of these species in relation to geologic and soil factors might well reveal similar ecologic isolation.

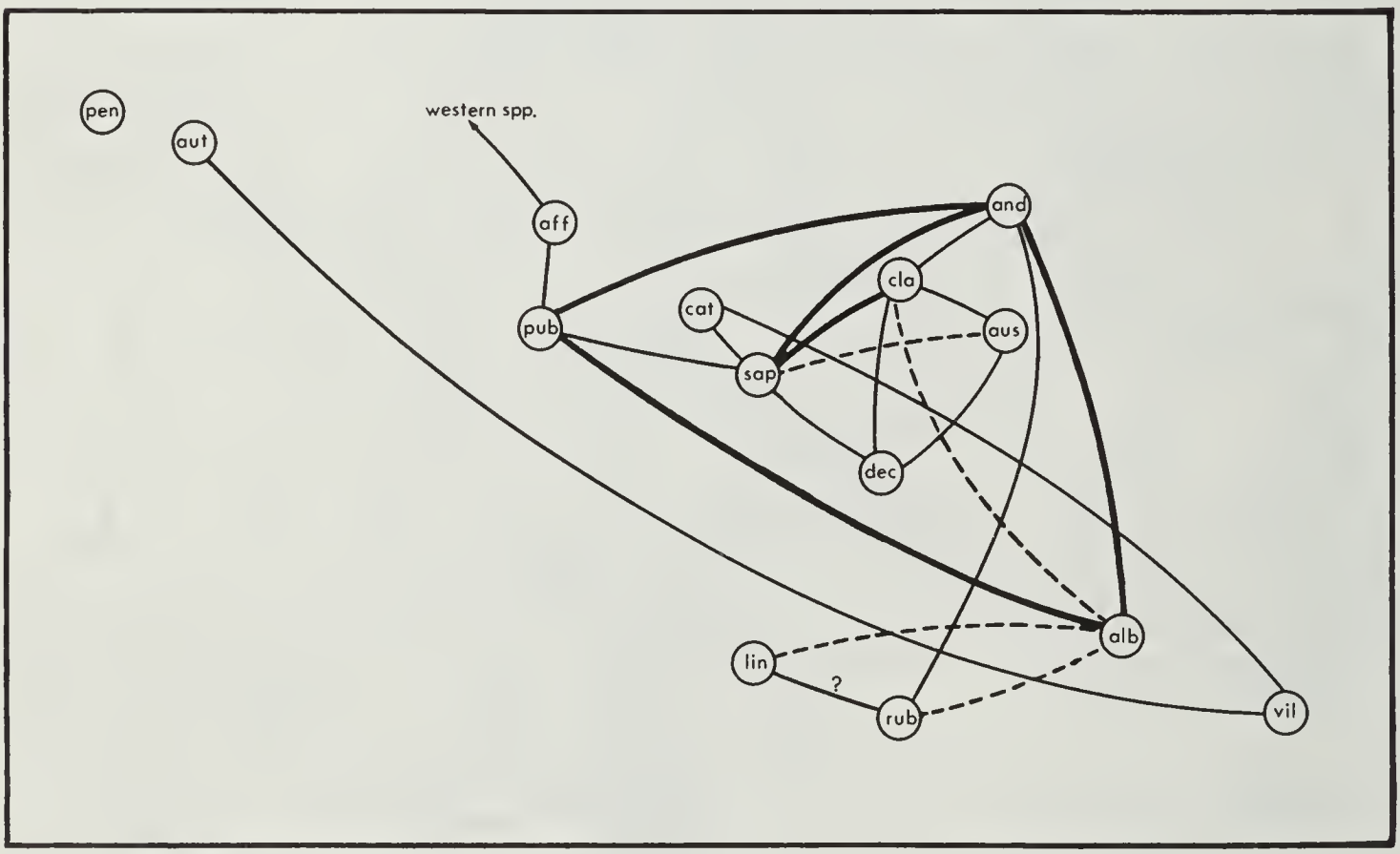

Fig. 7. Hybridization among *Gentiana* spp. of eastern and central North America. Abbreviations are the first three letters of the specific epithets of *G. affinis* Griseb., *G. alba* Muhl., *G. andrewsii* Griseb., *G. austromontana* Pringle & Sharp, *G. autumnalis* L., *G. catesbaei* Walt., *G. clausa* Raf., *G. decora* Pollard, *G. linearis* Froel., *G. pennelliana* Fern., *G. puberulenta* Pringle, *G. rubricaulis* Schwein., *G. saponaria* L., and *G. villosa* L. Positions of symbols represent approximations of morphologic similarity and presumed phyletic affinity, diverging from probable primitive species at the upper left, with solitary flowers, open corollas, large corolla lobes, and prolonged, subequally bifid corolla appendages. Heavier lines indicate natural hybridization known from five or more localities; lighter lines, natural hybridization known or suspected from fewer than five localities; broken lines, only artificial hybridization known.

SUMMARY

Gentiana linearis Froel. and *G. rubricaulis* Schwein. both occur in the Upper Great Lakes region. Although these species are closely related, they do not intergrade. They are evidently ecologically isolated, *G. linearis* growing in soils derived from granite and similar low-basic rocks, but *G. rubricaulis* in non-granitic soils. The sharpness and the extent of their differences seem comparable to those among other generally recognized species of *Gentiana,* and, along with features of the distribution patterns of these species, indicate that *G. rubricaulis* probably cannot be interpreted merely as an ecotype of *G. linearis* which differentiated as *G. linearis* spread northwestward during Wisconsin glacial recession.

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TERATOLOGICAL STAMENS AND CARPELS OF A WILLOW FROM NORTHERN MICHIGAN

Warren H. Wagner, Jr.
Botanical Gardens, The University of Michigan, Ann Arbor

The study of monstrosities has always intrigued biologists for their possible bearing on our understanding of evolution and growth. Collectors of plants in the Great Lakes region occasionally hear of aberrant specimens, even in the newspapers. I wish to describe and discuss here an example of a phenomenon which has previously been reported for flowers of willows, the sex organs of which, stamens and carpels, show more or less intergradation. These specimens provide fine demonstrations of the correspondence of parts in the two types of organs, and it is my hope that readers will be encouraged to make further searches for and analyses of such phenomena.

On May 22, 1954, along a roadside about 2 miles south of Germfask, Schoolcraft Co., in the Upper Peninsula of Michigan, Dr. E. G. Voss collected a specimen (*1934*) of the long-beaked willow, *Salix bebbiana* Sarg., which proved to have monstrous flowers. It was growing with normal staminate and pistillate willows of the same species; subsequent efforts to rediscover the plant in question have failed. Dr. Voss gave me some dried flowers which I cleared in 5 percent solution of sodium hydroxide to make the observations to be reported below. By gently staining the specimens and mounting them in diaphane on a microscope slide I could make out the corresponding parts more definitely.

THE NATURE OF PLANT TERATOLOGIES

Before describing the floral organs of this collection, I should make some general comments on the nature of monstrous developments in plants. One may well ask "Of what scientific interest are these freaks?" This is a fair question and one which deserves an answer, even if it is only a tentative one. It should be pointed out that there are all sorts of peculiar formations possible, and they are due to a multitude of causes, some of which we understand to some extent and some which remain entirely obscure. In 1964 the Ann Arbor *News* reported a plant of evening primrose, *Oenothera biennis,* discovered by a fourth-grade student, the photograph of which showed a massive club of flowers nearly a foot across. This phenomenon, which is found occasionally not only in evening primrose but also in such other plants as thistles, dandelions, mullein, sumacs, and blackberries, is known as "fasciation." The growing tip of the plant simply expands in one dimension as it grows, becoming broader and broader. So far as I know, the cause of this type of monstrosity is not yet known, but the condition in the familiar cockscomb (a cultivar of *Celosia argentea*) of the garden is controlled genetically and the monstrous development is fixed.

Fasciation is but one of a series of growth irregularities known in plants. For example, especially in ferns, there are numerous hybrids in which the parts develop asymmetrically and irregularly. In these, the abnormal shape appears to be related to a failure of the hereditary factors that control form to interact with

harmony (Wagner, 1962). The "doubled" flowers of many garden plants also have a genetic basis; in these, (as is illustrated especially well by the roses) many of the stamens have become transformed into petals, so that instead of having only five petals, the wild condition, the flower may have dozens of petals.

Sometimes the peculiarities of development are controlled by purely environmental or extraneous factors. There are certain experimental tobacco hybrids (Whitaker, 1924) which produce tumor-like outgrowths that are genetic in origin, but similar structures can also be induced artificially in normal plants by applying certain plant hormones (Whitaker, 1924; Brown & Gardner, 1937). As we have seen in the past decade, the use of weed killers may produce much altered growth patterns in plants if they survive. Strangely shaped plant specimens may also result from damage caused by mowing or by cattle or other domestic animals stepping upon the new, embryonic shoots (cf. Wagner, 1966). The possible causes for abnormal growth seem to be numerous. The resulting abnormalities range from organs which are nearly typical, all the way to completely disorganized plant tissues or tumors. For our purposes here, we shall confine our discussion to those abnormal plant parts which, although deformed, still bear some resemblance to the normal condition and can still be defined approximately as "leaves," "stems," or "flowers."

When we say "causes" we still have to recognize the superficiality of referring to such vague concepts as "genetic factors" or "environmental factors" as real causes. The basic questions involve what actually happens or what is upset in the process of forming the plant or its parts. The study of monstrous development is known as "teratology," and in recent years the subject has been fairly unpopular in botany.[1] Part of the unpopularity is due to our discouraging lack of clear understanding of plant development (all the way from genic action to tissue and organ formation).

There have been wild speculations about monstrosities. It is an old idea in biology that teratologies represent "throw-backs" or "atavisms" which show what ancestors were like. Heslop-Harrison (1952), who is one of the recent authors who grappled with this idea, concluded that "abnormalities may have significance in interpreting homologies of organs, but *cannot* be regarded as atavistic" (italics mine). This will be the basis of the interpretation of the willow flowers to be given below.

To illustrate how teratology may be used to clarify what are homologous organs, we can consider the familiar anomalies in roses in which floral parts are formed intermediate between sepals and petals, and between petals and stamens. Such specimens show that the floral appendages all belong to the same general category as the leaf. There is nothing particularly atavistic about these intermediate structures; indeed, all they show is that you can get intergrades between *existing* organs, not some organs of some ancestor of the distant past.

Other teratologies of roses are especially interesting when they involve the

[1] In medicine (perhaps as a result of the thalidomide tragedy which disfigured many hundreds of children in Europe), the study of teratology and related subjects seems to have undergone a renaissance, and it is possible that the same will happen in botany, especially as a result of newer experimental techniques for studying plant development.

growth of the whole flower; one of the theories of the flower is that it is a *determinate* shoot, i.e., that it corresponds to a vegetative shoot but its leaves become the floral parts and when the female organs are produced it stops growing. Occasionally in roses the shoot "grows through": after producing the floral parts it continues to grow, but now produces ordinary foliage leaves. In such specimens we have the unusual picture of a rose flower borne along a shoot, with normal foliage leaves below the flower and then coming out of the top of the flower!

Occasionally such abnormalities have been used to demonstrate homologies and to help resolve controversies about the nature of certain reproductive organs. The seed-bearing structure of the ginkgo tree, for example, has long been subject to speculation—is it a modified "sporophyll," i.e., fertile leaf, or is it a naked stem? Structures intermediate between the fan-shaped foliage leaves and stalk-like seed structures have been discovered which tend to support the interpretation that the "ovuliferous structure" of ginkgo is, in fact, a much-modified sporophyll (cf. illustrations in Zimmerman, 1959, pp. 402-403).

The umbrella-shaped spore-bearing organs in the cones of scouring rushes and horsetails, *Equisetum*, have also been debated. However, in 1939 Tschudy reported a complete series of structures from "sporangiophores" (sporecase-bearing organs) to ordinary vegetative sheath leaves, which demonstrated quite clearly the correspondence of these parts. He found these in teratological cones of *Equisetum telmateia,* a western species. More recently, Dr. R. L. Hauke in his investigations of Michigan *Equisetum* discovered a splendid example of this phenomenon in *E.* x *litorale,* a hybrid horsetail intermediate between common field horsetail, *E. arvense,* and the water horsetail, *E. fluviatile.* A hybrid colony covers a large part of an acre in Monroe Co., Michigan, not far from the village of Milan. There are hundreds of specimens with this abnormality. In this hybrid horsetail colony, the peculiarity of forming intermediate organs is probably genetically fixed, and maintained by vegetative reproduction.

THE MONSTROUS WILLOW FLOWERS

When we think of the flowers of willow we think first of the catkins, the "pussy willows"—clusters of dozens of much reduced florets and hairy parts. Typically a whole willow plant is either male, the catkins made up of all staminate flowers, or female, the catkins of all pistillate flowers. This arrangement assures cross-pollination. Interspecific hybridization is frequent and this causes one of the problems of identifying willows. Willow crosses are common enough to lead to some confusion between the species.

The willow flowers are borne in the axils of hairy scales or bracts. The individual flower lacks sepals or petals, but there are usually one or more yellowish, shiny glands which produce nectar. These are shown at the bases of the three staminate flowers at the upper left in Figure 1. The stamens of the male flower number two in the majority of species but may be one or as many as twelve in some. They are made up of long, delicate filaments topped by an anther of four pollen sacs. Pollination is accomplished by insects, or by wind, or both. The female flower is basically similar to the male flower in being borne in the axil of

a bract along the catkin and possessing one or more glands. Instead of having separate stamens, however, it has a single pistil, this a more or less stalked ovary made up of two or four carpels topped by the two- or four-lobed stigma. The pistil matures into a small capsule from which are produced numerous tiny black seeds, these floated on the wind by masses of long hairs. Even though the pollen- or seed-producing flowers lack obvious sepals or petals, the anatomical studies of Fisher (1928) led to the conclusion that the gland is the remainder of an ancient perianth, reduced now to a mere papilla and functioning secondarily as a nectary.[2]

The Voss collection of *Salix bebbiana* differs from the normal form of the species in having both types of sex organs in the same catkin. The sex organs also show all degrees of intergrades in their characteristics. There is nothing distinctive about the bracts, which are typically yellowish and slightly pilose, nor the glands, which are solitary, one per flower. No attempt was made to estimate the quantitative incidence of the different forms of flowers present, but Figure 1 illustrates the kinds of organs discovered.

In order to understand this series we can arbitrarily separate organs into the following forms:

1. Normal male flowers. These are are the three illustrated at the upper left, and show the basic structure of the stamens. A very long uniformly narrow filament is topped by the anther with its four pollen sacs. The latter, when mature, split longitudinally, releasing the pollen. The filament runs directly into the "connective" which is the extremely narrow band of sterile tissue connecting the pollen sacs. The top of the connective is seen merely as a depression between the lobes of the anther.
2. Intermediate form I. These organs differ from typical stamens primarily in the development of the connective. Now the connective is expanded, both laterally and terminally. The pollen sacs become more or less separated and moved around toward one side. There is also a tendency for the filament to become shorter and broader. An obvious stigma is still not present, the apex of the connective being represented only by a slightly projecting but naked tip.
3. Intermediate form II. The organ is almost perfectly transitional between

[2]It is interesting to note that in the related genus *Populus,* including aspens, poplars, and cottonwoods, there is a much more obvious perianth, the so-called "cup-like disk." In this genus wind-pollination is the rule. The plants, as in willows, are either male or female, but in his investigations on Michigan aspens, Dr. Burton V. Barnes found, as have previous workers (e.g., Erlanson & Hermann, 1928), a number of plants with a few to many bisexual flowers containing both normal pistils and normal stamens. Teratological organs were also found in *Populus* and included what appeared to be mainly fusions between organs—pistil, filament, and anther fused together; anthers attached to the ovary wall; or 2-3 anthers more or less joined (Barnes, pers. comm.).

Fig. 1. Free-hand drawings of flowers and separate sex organs from an unusual plant of *Salix bebbiana.* Specimens marked with Roman numerals are examples of different stages of intermediacy between stamens and carpels. All from one catkin of *Voss 1934.*

I
II
III
2 mm.

stamen and carpel. Now the pollen sacs (or ovules?) have moved entirely to one face of the connective, which itself has become much expanded and more or less inrolled at the margins. Also the beginnings of a stylar elongation are obvious and a more or less rudimentary stigma occurs. However, carpellary closure is little, if at all, evident.

4. Intermediate form III. Now the organs are obviously more carpel-like than stamen-like. They differ, however, from carpels in the following ways: (a) Although the style and stigma appear to be normally formed, fusion is still not complete in the ovary region so that the ovary is like a tube with a longitudinal opening along one side. (b) The ovules (or deformed pollen sacs?) are borne near the base of the opening and are irregular in size and arrangement.
5. Carpels. These are like those of typical pistillate flowers of *Salix bebbiana,* with one very important exception. In these anomalous flowers, the basic separateness of the organs characteristic of staminate flowers is retained, so that the "female flower" (i.e., one without any obviously male structures) appears to have two pistils. The ovary is normally composed of two carpels which themselves are fused into a compound ovary. It seems remarkable that the carpels have not fused with each other but have folded their margins together and have closed upon themselves.

Fig. 2. Diagrammatic illustration of the changes illustrated by the intergradient organs between stamens and carpels. Background guidelines to emphasize the corresponding parts.

Generally speaking, any given flower will have sex organs of approximately the same type but there is some irregularity in this respect, as shown in the drawings of whole flowers, those with two sex organs from the same flower together.

SIGNIFICANCE OF THE MONSTROUS WILLOW FLOWERS

As early as a half-century ago, Worsdell (1915, pp. 190, 191; pl. xlvi) commented on similar teratological conditions in willows found in England. What the morphogenetic significance of these abnormalities may be can only be speculated upon at this time. Perhaps they result from hybridization, or perhaps from upsets in the genetic factors which control whether a particular appendage is going to be a male organ or a female organ. It is conceivable that much can be learned about the developmental processes of floral organs by detailed studies of such teratological forms as these, and by comparing different examples of them. I find it especially interesting that in the present material I observed no fusions of parts at all, including even the most carpel-like structures, the ones which would have been most expected to fuse. This is in striking contrast to what Worsdell reported in "*Salix cinerea* var. *monodelpha*" (op. cit.). In his words ". . . in the normal male catkins the stamens frequently become united, and this is constantly the case in the variety *monodelpha*. These facts clearly prove the close alliance which exists between stamens and carpels."

It seems to me that the major significance of the collection described here is in showing what Worsdell called "the close alliance which exists between stamens and carpels." The organs are, it is true, very different from one another in their typical expressions, and it is hard to visualize the corresponding parts. Yet in the present study we seem to have excellent demonstration of the homologies of parts. The stages illustrate graphically to what part of the stamen each of the parts of the carpel corresponds—the stigma, the style, the ovary, the ovules, and the stalk, as shown diagrammatically in Figure 2. It makes evident how greatly reduced the anther connective is, when we realize that this simple and narrow band of tissue joining the pollen sacs is homologous to the massive walls of the ovary, as well as its style and stigma.

If the living remains of primitive flowering plants were not so complete, as shown in the studies of the late I. W. Bailey and his students of Harvard University, we might doubt that the simple anther connective could correspond to the leaf-like walls of the carpel. There are living genera of primitive flowering plants in which the stamen is normally more or less leaf-like, and the pollen sacs are borne upon the reduced blades, including genera in such families as Degeneriaceae, Himantandraceae, and Magnoliaceae. Families like these in which the "connective" is more or less blade-like also possess such other primitive features as wood without vessels or with primitive vessels; flowers with a spiral cone-like arrangement of parts, the parts numerous and of indefinite number; the carpels also essentially leaf-like; and the pollen of a primitive form with only a single germination furrow. For students of Great Lakes plants, the families Ranunculaceae, Berberidaceae, Lauraceae, and the genus *Liriodendron* in the Magnoliaceae are local plants of fairly primitive floral organization.

Normal stamens and carpels of willows, on the other hand, are among the most specialized forms we know, but a comparison of the Stage I intermediates described and figured above show a remarkable likeness to some of those of the "ranalian" families mentioned. The stamens of primitive flowering plants have a similarly shorter filament, broader and readily visible connective, and pointed tip that extends beyond the pollen sacs.

It should prove interesting to discover more specimens of willows like these. Besides the general teratological questions already presented above, there are others. For example, what of the anatomical changes involved in the transition from stamens to carpels? The microscopic structure of the walls of the normal pollen sacs is very different from that of the ovules. What are the intermediates like? How do the integuments correspond, if at all, to parts of the pollen sacs? How does pollen formation intergrade with the formation of the embryo sac? Such questions would be difficult to answer from the dried material with which we worked here; and for this reason we should attempt to find (and mark!) more examples. This means that we must examine each willow specimen carefully with a good hand lens at the time of flowering. That *Salix bebbiana* may be disposed toward abnormalities is already suggested in the reports by Emma Cole (1901) from Grand Rapids and by Mr. and Mrs. Hanes (1947) from Kalamazoo County that in this species staminate and pistillate flowers occur together.

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A PRELIMINARY REPORT ON THE DISTRIBUTION OF GYMNOSPERMS IN MICHIGAN

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In the course of preparing a concise account of the gymnosperms of Michigan, I have become aware how poorly represented most of these plants are in the herbaria of the state. Distribution maps based on currently known specimens may be quite misleading compared to the actual ranges of the species concerned. Hence, a series of preliminary county-distribution maps is here presented, in the hope that it will inspire botanists in the field this summer to improve, by making good collections, the basis for future maps. Only native (not planted) individuals should be collected for this purpose.

Reasons for the poor representation of gymnosperms (and, for that matter, of most trees) in herbaria probably include an erroneous assumption that the plants are so common and conspicuous that sufficient specimens must already have been collected, as well as the fact that making good specimens sometimes is difficult. While large woody plants are conspicuous through a long season, finding and reaching collectible portions bearing flowers or fruit (or cones) is not always easy; and herbarium curators generally frown on sterile specimens of plants. Spruces (*Picea* spp.) and hemlock (*Tsuga canadensis*) make particularly discouraging collections since when dry they shed their needles, which must be placed in a packet or envelope on the herbarium sheet. Cones tend to make specimens large and bulky compared to those of many plants, giving the collector another excuse to ignore conifers.

Specimens will be more valuable the farther they come from the range suggested by the maps. An additional record, in other words, from an adjacent county is much less significant than one from a hundred miles farther south than previous specimens. Extension of known limits of range should give collectors a special challenge. The more significant a record is, the more justified a sterile specimen may be. Ordinarily, young cones on the branchlets, or older separate cones carefully marked or tagged to make clear the specimen with which they belong, add immensely to the value of herbarium material; unless quite small or green, cones should not be pressed with the rest of the specimen. As with any large plant, the collector should record on the label the overall stature of the tree or shrub from which the specimen came, as well as the date, exact location, habitat, and his name.

The distribution maps include a dot in each county from which a specimen has been examined.[1] In addition, certain islands or island groups have been

[1]The maps are based on specimens examined in herbaria at the following institutions: University of Michigan, Michigan State University, Wayne State University, Cranbrook Institute of Science, University of Michigan Biological Station, and Grand Valley State College. When additional herbaria have been checked, naturally some improvements in the maps will result.

mapped separately from the mainland of their respective counties: Isle Royale (Keweenaw Co.), Drummond Island (Chippewa Co.), Mackinac, Round, and Bois Blanc Islands (Mackinac Co.), the Beaver Islands (Charlevoix Co.), and the Manitou Islands (Leelanau Co.). During the period 1963-1966, Paul O. Rudolf and collaborators issued a series of "Research Notes" from the Lake States (now North Central) Forest Experiment Station, on the botanical and commercial ranges of several conifer species: LS-15 (jack pine), LS-62 (red pine), LS-63 (white pine), LS-73 (white spruce), LS-74 (black spruce), NC-16 (balsam fir), NC-17 (tamarack). In several instances, these are based on information which indicates more extensive ranges than the maps here; major range extensions are mentioned below, with the Research Note cited merely by number.

Identification keys and some supplementary remarks have been included in this report. Unless otherwise specified, all references to cones are to the female cones.

KEY TO FAMILIES OF MICHIGAN GYMNOSPERMS

1. Leaves opposite or whorled, scale-like or needle-like . . . . . CUPRESSACEAE
1. Leaves alternate or in clusters, needle-like or linear
   2. Fruit red and berry-like; leaves flattened, with strongly decurrent bases, persistent, appearing 2-ranked, all green on both sides (may be yellower beneath) . . . . . TAXACEAE
   2. Fruit a dry woody cone; leaves flattened or not, but if so, not as above (i.e., not decurrent, readily falling when dry, not 2-ranked, and/or with distinct white lines) . . . . . PINACEAE

TAXACEAE

1. *Taxus canadensis* Marsh. Map 1. Ground-hemlock; Yew

The only native species of the family in this area. Various cultivated yews have similar fruit and needles (flat, ± uniform yellow-green beneath, with decurrent bases) to those of the native plant—even though some of them are upright, like small trees. Our native species is a spreading monoecious shrub (most other species are dioecious), with attractive red "fruit." The latter consists of a single seed surrounded by a fleshy cuplike structure (the aril). The bright red, pulpy aril is edible, but the seed is reputed to be poisonous, as is the foliage, at least to some animals. (The seed, even if it contains a poisonous principle, may pass safely through the digestive tract if not chewed.) The foliage is reported to have been used by several Indian tribes in the Michigan region and Quebec in the making of a beverage. It is heavily browsed by deer and moose in Michigan. The European yew (*T. baccata* L.) is often cultivated for ornament and is apparently much more poisonous.

PINACEAE

Key to the Genera

1. Leaves needle-like, all or mostly grouped in definite clusters on short shoots
   2. Leaves deciduous, crowded and numerous on short lateral shoots (alternate leaves on new twigs); cones less than 2 cm long . . . . . 1. LARIX

2. Leaves evergreen, in clusters of (normally) 2 or 5; cones more than 2 cm long . . . . . 2. PINUS
1. Leaves flattened or 4-sided, alternate (spiraled), not in definite clusters
3. Leaves persistent on dry branches, sessile, separating cleanly from an orbicular leaf-scar without any raised projection, the twig hence basically smooth; cones erect, 3.5-6.5 cm long, the scales falling at maturity from persistent central axis . . . . . 3. ABIES
3. Leaves readily falling from dry branches, leaving persistent peg-like bases (sterigmata), the twig hence very rough; cones pendent, (1) 1.3-6 cm long, falling entire at maturity
4. Leaves flattened, rounded at apex, distinctly short-stalked in addition to the persistent narrow base . . . . . 4. TSUGA
4. Leaves ± 4-sided, acute or sharp-pointed, sessile on the persistent peg-like base . . . . . 5. PICEA

1. LARIX

L. laricina (DuRoi) K. Koch Map 2. Larch; Tamarack

The only native species of the genus in eastern North America. The European *L. decidua* is sometimes planted; it differs in its larger cones, with pubescent scales.

2. PINUS

A detailed study, largely on the ecology and silviculture of the two important timber species, is represented by the following reference: K. W. Horton & G. H. D. Bedell. 1960. White and Red Pine. Canada Dep. Northern Affairs & Natl. Resources. Forestry Branch, Bull. 124. 185 pp.

Key to the Species

1. Needles usually 5 in a cluster, ± triangular in section; membranous sheath surrounding base of each needle cluster deciduous; cones cylindrical, at least twice as long as wide . . . . . 1. *P. strobus*
1. Needles usually 2 in a cluster, ± semicircular in section; membranous sheath surrounding base of each needle cluster ± persistent; cones short-ovoid, much less than twice as long as wide
2. Needles ca. 8-15 cm long, straight; bark of older branches and trunk reddish; cones generally deciduous, subterminal on the branchlets . . . 2. *P. resinosa*
2. Needles ca. 1.5-3 (6) cm long, ± twisted; bark of older branches and trunk dark gray to black; cones generally long-persistent, lateral on the branchlets . . . . . 3. *P. banksiana*

1. *P. strobus* L. Map 3. White Pine

The needles of white pine are lighter in color, softer in texture, finer and less stiff than those of our other two species. The familiar and important white pine is the official state tree of Michigan—a fitting designation, for this was the backbone of the lumber industry, particularly in the last quarter of the 19th century, when Michigan led the nation in lumber production. Here were the finest stands of this species in the world: trees attaining at their best 5-7 feet in diameter and 150-200 feet in height, although usually smaller.

2. *P. resinosa* Aiton Map 4. Red Pine

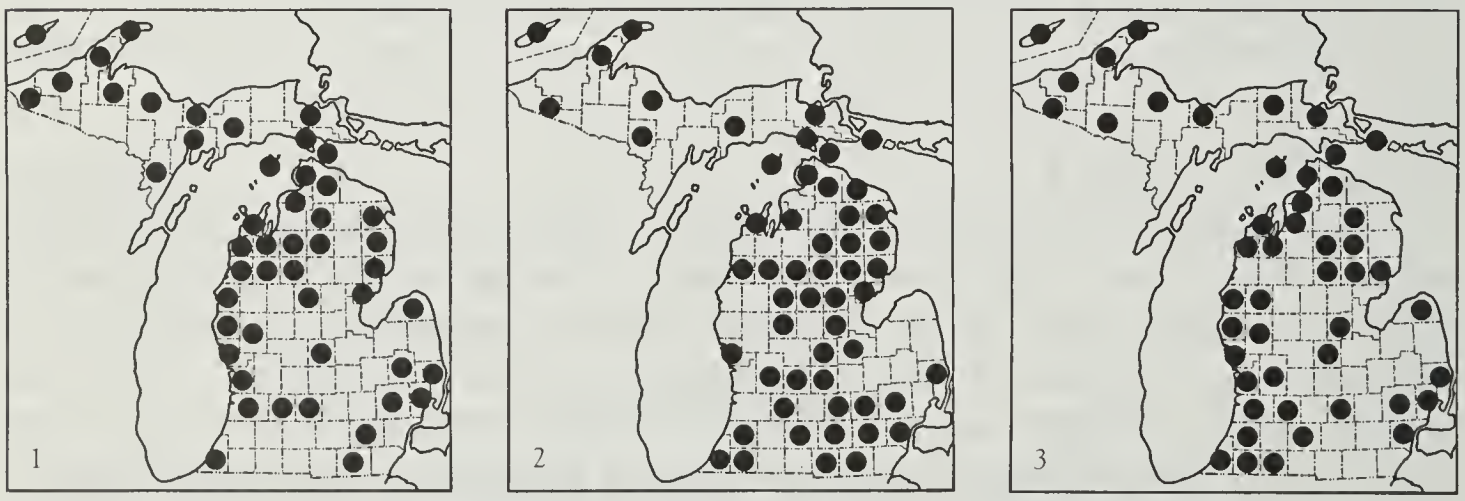
This stately tree is frequently called by the misleading name "Norway Pine"; it grows naturally only in northeastern North America. A somewhat similar European species, *P. nigra* (Austrian Pine), is occasionally planted. Its bark is gray or darker in contrast to the very distinctive reddish flaky bark of *P. resinosa;* and the stiff needles do not break cleanly upon bending, compared to those of *P. resinosa*, which snap sharply.

In some ways red pine is ecologically intermediate between white pine and jack pine, growing with the former on better soils and with the latter on light sandy soils, although white and jack pines seldom grow together. The range extends south to Van Buren County on the west side of the state and to Gratiot County in the central part (LS-62).

3. *P. banksiana* Lamb. Map 5. Jack Pine

The needles are ± abruptly obtuse to acute but blunt at the apex. In the similar *P. sylvestris* (Scots Pine; Scotch Pine), the needles average a bit longer than in *P. banksiana,* and they tend to taper to sharp tips as well as being more silvery in aspect. The curved cones of *P. banksiana* tend to point forward toward the ends of their branches and are long-persistent, while the more readily deciduous cones of *P. sylvestris* are ± horizontal or reflexed, pointing toward the bases of their branches. The bark of *P. sylvestris* is a distinctive orange-brown, noticeable especially on the upper part of the trunk. While the latter species is widely planted, it does not often become established on its own. Old plantations seen from highways, as in Roscommon and Crawford counties, may give the impression of stands of a native tree.

The range of jack pine extends south near Lake Michigan to Berrien County and the south end of the lake (LS-15). It has been estimated that jack pine predominates in over a million acres of forest in Michigan, over half of it in the northern Lower Peninsula, where certain restricted areas of young growth are the home of our most famous bird, the Kirtland's or "Jack Pine" Warbler, which breeds nowhere else in the world.



Figs. 1-3. Distributions of Michigan gymnosperms: (1) *Taxus canadensis*; (2) *Larix laricina*; (3) *Pinus strobus.*

3. ABIES

Abies balsamea (L.) Mill. Map 6. Balsam Fir

The only species of the genus in our region. The young twigs vary from densely to sparsely puberulent. The needles usually appear ± 2-ranked, in flattened sprays, and are usually rounded to slightly notched or 2-toothed at the apex, 0.8-2.5 (3.2) cm long. However, especially on older cone-bearing branches, the needles may curve upward, giving a bushy spruce-like appearance to the branches, and may be quite acute. Such needles tend to be shorter and thicker than the flatter, longer needles of sterile lower branches. But all are readily recognized by the smooth round leaf scars. This species is reported south to Oceana, Newaygo, and Mecosta counties (NC-16).

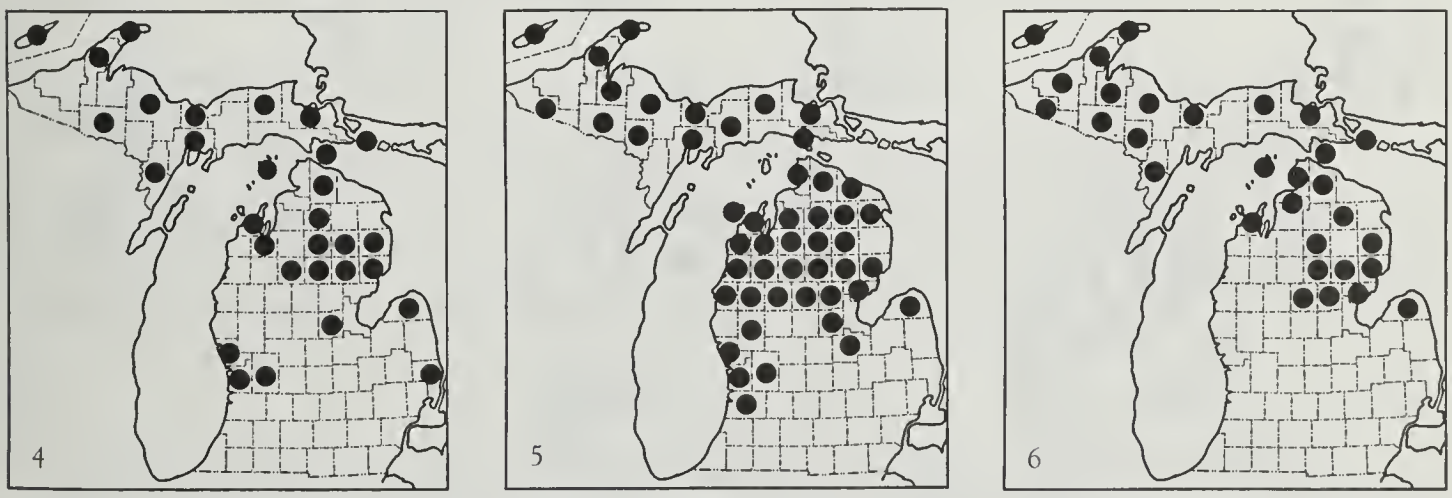
This aromatic plant is a popular Christmas tree since the needles do not fall readily as do those of the spruces. The blunt fragrant needles are used in balsam pillows, and the "Canada balsam" of the microscopist is distilled from the bark and needles. Resin-filled pustules are characteristic of the bark of this species, and the cones are often heavily resinous.

4. TSUGA

Tsuga canadensis (L.) Carr. Map 7. Hemlock

The only species of the genus in our region. The young twigs are ± densely pubescent. The short needles, mostly 6-13 (16) mm long, in flat sprays, and the small cones, mostly 13-22 mm long, are characteristic of this species. Even shorter needles occur on the upper side of the twigs, closely appressed and thus displaying conspicuously the prominent white lines of the under surface. This characteristic is not easily seen on dried specimens, because the needles are so readily deciduous, but it is a useful field mark. The needles of hemlock are minutely toothed toward the rounded apex and have distinct petioles about 0.5 mm or a little longer.

Hemlock inner bark is purple, and the bark has been the main source of natural tannin for the leather industry. This genus is not native in Europe, and should not be confused with the poison-hemlock of Socratic fame. The latter is a herb in the Umbelliferae, *Conium maculatum* L.



Figs. 4-6. Distributions of Michigan gymnosperms: (4) *Pinus resinosa;* (5) *Pinus banksiana;* (6) *Abies balsamea.*

5. PICEA

Key to the Species

1. Young branchlets mostly ± densely fine-pubescent; leaf bases below the peg-like sterigmata ± obscure on 1-year-old twigs; cones rather globose, (1) 1.5-2.8 cm long, the scales with slightly irregular or erose margins, woody and rigid at maturity . . . . . 1. *P. mariana*
1. Young branchlets glabrous; leaf bases prominent below the sterigmata on 1-year-old twigs, appearing to cover them with ridges and grooves; cones cylindrical, (2.5) 3-6 cm long, the scales nearly or quite entire, thinner and more leathery . . . . . 2. *P. glauca*

1. *P. mariana* (Mill.) BSP. Map 8. Black Spruce

The sterigmata tend to be widely spreading in this species, even at right angles to the twig, while in the next they tend to be strongly ascending. The needles are quite variable in size and shape and sharpness. It has been reported that the needles of seedlings of white spruce are minutely denticulate, while those of black spruce are entire; there is no such distinction on mature needles, and it should be carefully checked on seedlings.

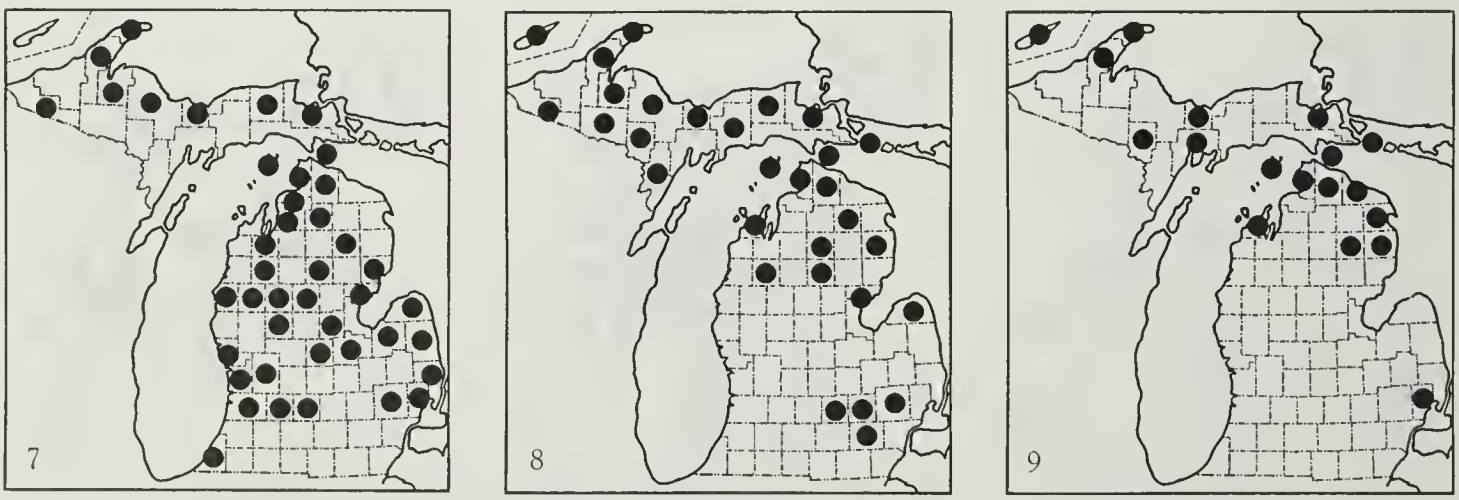
This species is the usual host of dwarf mistletoe, *Arceuthobium pusillum,* although the parasite has occasionally been found on white spruce in the vicinity of the Straits of Mackinac (Beaver Island; Wilderness State Park, Emmet Co.; Bois Blanc Island; and Drummond Island). Black spruce is reported south on the west side of the state to Ottawa and Kent counties (LS-74).

2. *P. glauca* (Moench) A. Voss Map 9. White Spruce

The needles may be up to 18 mm long, usually averaging a little longer than those of the black spruce (see above). This species is reported south to Newaygo, Mecosta, and Bay counties (LS-73). *Picea abies,* the Norway spruce, with drooping branchlets and cones at least twice as large as white spruce, is often planted as an ornamental.

CUPRESSACEAE

In some manuals, this family has been included in the Pinaceae.



Figs. 7-9. Distributions of Michigan gymnosperms: (7) *Tsuga canadensis;* (8) *Picea mariana;* (9) *Picea glauca.*

Key to the Genera

1. Mature cones ca. 8-15 mm long, brown and ± woody, the elongate scales distinct; leaves all opposite and appressed, scale-like, dimorphic (a pair of opposite strongly keeled leaves at right angles to adjacent pair of flat leaves); plant a tree . . . . . 1. THUJA
1. Mature cones up to 8 (10) mm long, green or bluish, fleshy and berry-like; leaves opposite or whorled, needle-like or if scale-like and appressed then quite uniform (none keeled); plant a tree with needle-like leaves or a shrub . . . . . 2. JUNIPERUS

1. THUJA

Thuja occidentalis L. Map 10. Arbor Vitae; Northern White-cedar

In addition to this one species in our area, there is another North American one in the Pacific Northwest. This is the characteristic tree of "cedar" swamps. The youngest seedlings have opposite or whorled flattened needle-like leaves, but the first branches have the characteristic scale-like leaves. The flat unkeeled leaves (i.e., those on top and bottom of twigs in contrast to the keeled leaves straddling the sides) have a ± prominent resin gland near the apex; this is especially evident on the lower leaf.

The true cedar (*Cedrus*) of the Old World is quite different; it has foliage somewhat like that of *Larix,* but evergreen, and the cone scales fall separately like those of *Abies.*

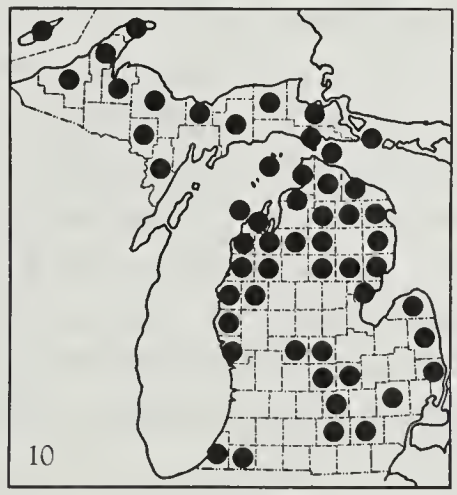


Fig. 10. Distribution of *Thuja occidentalis* in Michigan.

2. JUNIPERUS

The female cones are berry-like and dark bluish, often glaucous. The volatile oil they contain is the source of the distinctive flavor of gin. One often sees on *Juniperus* colorful orange galls caused by rust fungi of the genus *Gymnosporangium,* an important disease of apples and related plants.

Key to the Species

1. Leaves in whorls of 3, all awl-like, articulated at the base, not decurrent; cones on very short, scale-covered peduncles in the axils of awl-like leaves . . . . . 1. *J. communis*
1. Leaves mostly opposite, some or all scale-like (awl-like leaves when present often whorled but *not* articulated, decurrent at base); cones

apparently terminal on short, scale-covered peduncles or branchlets like the branchlets from which they arise

2. Plant an erect small tree with central trunk, growing in southern Michigan; fruit on ± straight, ascending peduncles (or branchlets) . . . 2. *J. virginiana*
2. Plant a prostrate trailing shrub, growing in northern Michigan; fruit usually on ± arched or recurved peduncles . . . . . 3. *J. horizontalis*

1. *J. communis* L. Map 11. Common or Ground Juniper

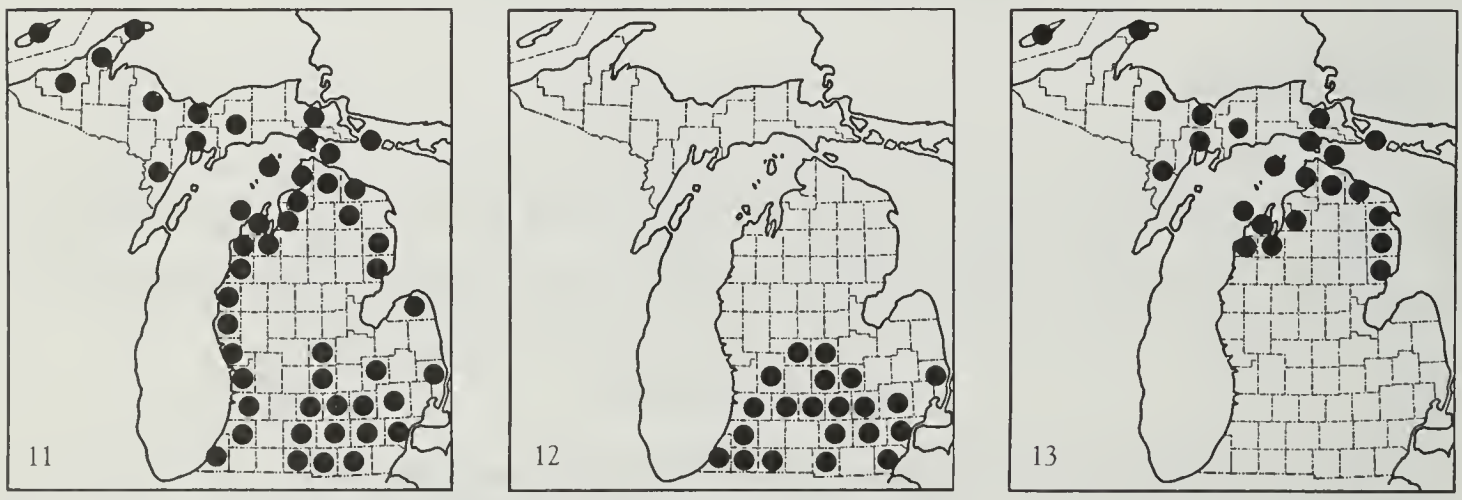
Most of our plants are var. *depressa* Pursh, a ± decumbent form whose large cup- or saucer-shaped mats are characteristic of dunes and sandy places. Some plants in the vicinity of the Sleeping Bear dunes (Leelanau Co.) are unusually tall and robust. The upper surface of the needles is slightly concave and is generally marked with a conspicuous white stripe the entire length. Various forms of the species are cultivated for ornament.

2. *J. virginiana* L. Map 12. Red-cedar

This species is said to have 3-5 seeds in each berry-like cone, while the next has only 1 or 2. Both species may have sharp awl-like leaves on the young growth and seedlings (or sometimes after injury), while the leaves on old growth are scale-like and overlapping. Red-cedar is probably more common and widespread in the state now than it was before the clearing and exposure of the landscape and subsequent spread by seeds eaten by birds. It is often planted.

3. *J. horizontalis* Moench Map 13. Creeping Juniper

I can see no consistent difference in leaf shape by which to distinguish this species from the preceding; both have a wide range of scale shapes and awl-like leaves, chiefly the former. Sterile specimens for which the collector carelessly omitted from the label any statement regarding the stature of the plant may usually be distinguished by the definitely one-sided aspect of the trailing branches of *J. horizontalis*—which also grows in Michigan only north of the native range of *J. virginiana.* Where the two species overlap (in Wisconsin and Maine) hybrids are reported. A very blue-glaucous form grows on Mt. Bohemia, Keweenaw County, and the species is found elsewhere on rock in the northwestern Upper Peninsula and on Isle Royale. In the remainder of the state, it is confined to sandy shores and dunes of the Great Lakes.



Figs. 11-13. Distributions of Michigan gymnosperms: (11) *Juniperus communis;* (12) *Juniperus virginiana;* (13) *Juniperus horizontalis.*

REVIEW OF THE STATUS OF SOME GREEN ALGAE IN THE GENUS *COELASTRUM*

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The genus *Coelastrum* was established by Naegeli in 1849 when he described some plants which he obtained from pools in peat diggings at Zürich. He established two species, *Coelastrum sphaericum* and *C. cubicum,* indicating *C. sphaericum* as the type. Approximately 20 species are known for the genus and have been summarized in a key by Ventatamaran and Goyal (1962). However, there is doubt regarding the validity of some of these taxa. Our studies (1966) have shown that some forms tend to be polymorphic and it is not possible to delimit all species solely on the basis of morphology.

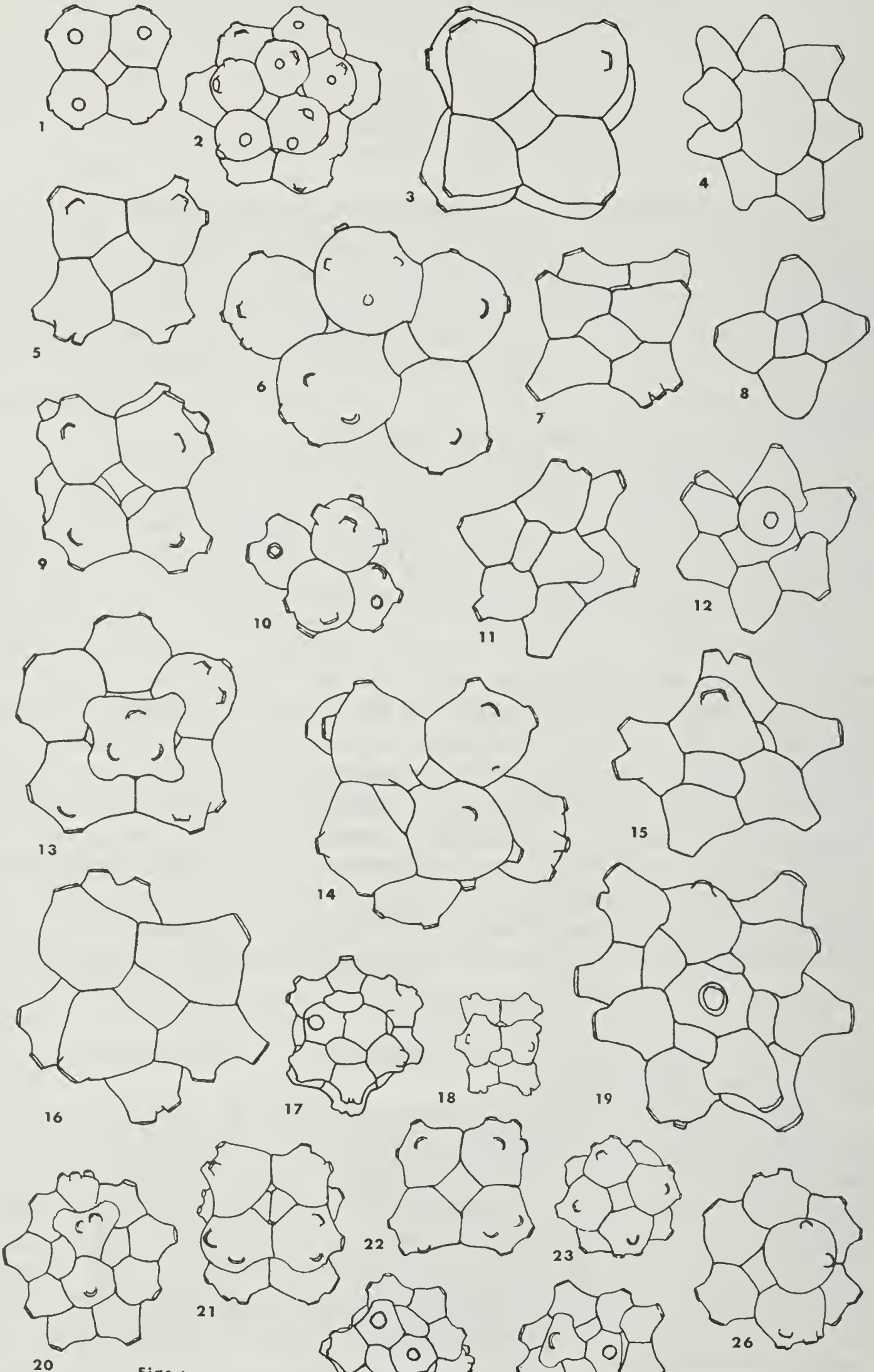
The coenobium of *C. sphaericum* illustrated by Naegeli (1849) could easily be considered identical to coenobia (Figs. 4, 7, 8, 12) which we obtained from our most recent cultures[1] of *C. proboscideum* v. *dilatatum* Vischer[2] and those which Vischer (1927) lists as varieties of *C. proboscideum.* These same cultures also produced many coenobia (Figs. 3, 5, 9, 13) which have the same appearance as Naegeli's *C. cubicum.* Some plants (Figs. 6, 10) resemble *C. scabrum* Reinsch.

Rayss as early as 1915 had indicated that some forms are polymorphic when she recognized "sphaericum" and "cubicum" forms in her cultures of *C. proboscideum.* Earlier, Chodat (1902) had described *C. proboscideum* as having: "Cenobes comme ceux du *C. sphaericum,* mais chaque cellule terminée par une trompe plus marquée; la variabilité est extreme dans cette espèce, dont plusieurs états correspondent à s'y meprende au *C. sphaericum.*" Julia Snow (1903) also recognized the difficulty in defining the taxa when she stated: "A specimen was found agreeing in every respect with *Coelastrum cubicum* Näg., which produced typical coenobia of *Coelastrum proboscideum,* so that the species of *Coelastrum cubicum* is to be questioned." Wille (1919) obtained "sphaericum" plants and some forms which he considered to be intermediate between *C. sphaericum* and *C. cubicum* from germinated resting spores of *C. cubicum.* The writer (1962) has also germinated resting spores of a *Coelastrum* collected from Lake Huron and has obtained from a single coenobium "sphaericum" or "proboscideum," "cubicum" and "intermediate" types.

The "cubicum" growth form is not often found in collections and some records of its occurrence are listed below. Korschikov (1953) in his paper on the algae of the area of the North Donets Biological Station near Kharkov, Ukraine, illustrated the plant (Fig. 1) and remarked: "I have serious doubts regarding its independence—and more detailed description of this species should be made." He also mentioned that the forms he personally repeatedly observed happened to be eight-celled or, more rarely, sixteen-celled coenobia. The writer has identified "cubicum" plants (Fig. 18) from material collected in a beach pool at the

[1]Grown in modified Bristol's solution, minus nitrogen, with 10 grams glucose added per liter.

[2]Indiana University Culture Collection, No. 282.



Figs.:
1,2 10μ
3–16,19 10μ
17,18,20–26 10μ

sandy margin of Douglas Lake, Michigan and also in collections (Figs. 21, 22) taken from a bog habitat at Port Radium, N.W.T., Canada. We have also described coenobia from these areas which might be defined as being intermediate in morphology between the "sphaericum" or "proboscideum" forms and "cubicum" forms (Figs. 17, 24, 25). As mentioned earlier in this paper we found coenobia in our cultures of *C. proboscideum* v. *dilatatum* which could be identified with published figures representing *C. proboscideum, C. cubicum, C. sphaericum* and *C. scabrum.* (It is interesting to note the similarity between our "scabrum" form (Fig. 6) and Korschikov's "cubicum" form (Fig. 2).) The "sphaericum - proboscideum," "cubicum" and "scabrum" forms which we have described above apparently occur in nature only in habitats such as bogs and pools which are low in available nitrogen. Similar forms produced in our nitrogen deficient media would indicate that this is true.

Further investigations involving culture studies are necessary to determine the range of phenotypic plasticity ofother members of the genus.

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Fig. 1. Korschikov's "cubicum" form from the Ukraine.
Fig. 2. An 8-celled form which Korschikov named "cubicum."
Figs. 3, 5, 9, 13. "Cubicum" forms from our cultures.[a]
Figs. 4, 7, 8, 12. Forms from our cultures[a] which resemble Naegeli's fig. of *C. sphaericum.*
Figs. 6, 10. "Scabrum-like" forms from our cultures.
Fig. 17. Plant intermediate between "proboscideum" or "sphaericum" forms and "cubicum" form, from Sedge Pool, Douglas Lake, Michigan.
Fig. 21, 22. "Cubicum" forms from Port Radium, N.W.T., Canada.
Fig. 18. "Cubicum" form from Sedge Pool, Douglas Lake, Michigan.
Figs. 16, 19, 11. "Sphaericum" or "proboscideum" - "cubicum" intermediate forms from our cultures.[a]
Figs. 20, 24, 25. Intermediates from Port Radium, N.W.T., Canada.

[a]Bristol's minus nitrogen with 10 gm. glucose added per liter.

BRYOPHYTES NEW TO MICHIGAN

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During the past year a concentration of bryological effort both in the field and in the laboratory has resulted in numerous additions to the moss flora of the state, some of them of unusual interest. In addition to the nine species and two varieties listed below, several records of interest will be published elsewhere by Dr. Wolfgang S. G. Maass, who collected *Sphagna* in the vicinity of Douglas Lake and also in the Upper Peninsula last summer, by Dr. Paul L. Redfearn, who taught at the Gull Lake Biological Station and collected mosses in the southern part of the state last summer, and by Mr. Samuel J. Mazzer who has recently found at least one moss new to the state. We have seen and confirmed all of their additions to the flora.

MUSCI

Brachythecium curtum (Lindb.) Limpr. Cheboygan Co.—Reeses Bog, north of Burt Lake, *G. E. Nichols 157,* June-Aug. 1920 (MICH); Gorge of Carp Creek, north of Burt Lake, *R. R. Ireland, Jr.,* July 1961 (US).—Very likely all American reports of *B. starkei* (Brid.) BSG can be referred here. Though closely related to *B. starkei, B. curtum* has a distinctive aspect because of loosely spreading, more or less complanate, and more gradually acuminate leaves. The range can be confirmed, insofar as we have studied it, as northern and central Europe and eastern North America from Nova Scotia to Minnesota and Michigan and southward to North Carolina.

Calliergidium pseudostramineum (C. M.) Grout var. *plesiostramineum* (Ren.) Grout. Delta Co.—In dryer parts of *Carex lasiocarpa* association, in beach pool, Big Bay de Noc, *H. A. Gleason, Jr. 2424,* Aug. 23, 1939 (MICH).—Apparently known otherwise only from two Alaskan localities.

Dicranella cerviculata (Hedw.) Schimp. Alger Co.—On moist sandstone, Pictured Rocks, *A. J. Sharp,* July 22, 1955 (US). On moist sand, ledge of cliff, Pictured Rocks at Miner's Castle, *N. G. Miller 4391,* with *Pogonatum capillare,* Aug. 6, 1967 (MSC).—Circumpolar; Alaska to British Columbia, Labrador to Michigan and New Jersey.

Dicranella schreberiana (Hedw.) Schimp. var. *robusta* Schimp. ex Braithw. Cheboygan Co.—On wet, sandy shore, Douglas Lake, *G. E. Nichols,* June-Aug. 1920 (MICH). Gorge of Carp Creek, *Frances E. Wynne 2692,* July 24, 1942 (CAN). Mackinac Co.—Bois Blanc Island, *Frances E. Wynne 2566,* July 8, 1942 (CAN). Ontonagon Co.—On bank along Lake Superior, Porcupine Mountains, *G. E. Nichols & W. C. Steere,* Aug. 20-27, 1935 (MICH). Presque Isle Co.—On bank

of small river running into Lake Huron at Hammond Bay, *W. C. Steere 3166,* July 17, 1941 (MICH).–Specimens have been seen from England, Sweden, and Denmark, as well as British Columbia and Alberta and numerous localities in the East, from Maine to Michigan and Ontario, south to New York and New Jersey.

Fissidens bushii (Card. & Thér.) Card. & Thér. Branch Co.–Coldwater, *E. B. Mains,* April 7, 1913 (MICH). Eaton Co.–On alluvial soil, swampy forest along Grand River below the dam, Fitzgerald Park, just northwest of Grand Ledge, *N. G. Miller 3859,* April 9, 1967 (MSC). Van Buren Co.–On clay in hayfield, South Haven, *Irma Schnooberger 54,* Aug. 20, 1937 (MICH). Washtenaw Co.–On soil, Saginaw Forest, west of Ann Arbor, *Florence Hoseney,* April 14, 1967 (MICH).–An endemic of eastern North America, from Maine to Ontario and Michigan, south to Florida and Texas; commonly confused with *F. taxifolius* Hedw.

Grimmia pilifera P.-Beauv. Iron Co.–On granite rock, Horse Race Rapids, *Evelyn Wagoner, Flora Kubsch & Margaret Feigley,* Aug. 18, 1948 (MICH).–Widely distributed in eastern North America, also found in British Columbia, Mexico, and Japan.

Isopterygium distichaceum (Mitt.) Jaeg. & Sauerb. Eaton Co.–On moist earth in open woods, west of Fitzgerald Park, just northwest of Grand Ledge, *H. T. Darlington 8,* May 1951 (MSC).–This species is rather uncommon but widely distributed in eastern North America; we have seen specimens from Illinois, Maine, North Carolina, New Jersey, and Tennessee. Dr. R. R. Ireland, Jr., who has recently monographed the genus, kindly determined this specimen.

Plagiothecium latebricola BSG. Muskegon Co.–On decayed log (probably of *Tsuga*), Norton Township Park, *A. I. Gebben,* May 29, 1964 (MICH).–An apparently rare species of modest appearance, probably easily overlooked in the field or discarded without naming in the laboratory. Northern and central Europe; Massachusetts to Ontario and Wisconsin, south to New Jersey.

Scopelophila ligulata (Spruce) Spruce. Alger Co.–On sandstone outcrop, Pictured Rocks, Miner's Castle, *R. R. Ireland, Jr. 4525,* Aug. 2, 1961 (US). On moist sandstone, wall of gorge some distance below Tannery Falls, *L. E. Anderson 20053,* Aug. 6, 1967 (MICH).–A rare, yet widely scattered species, usually found on copper-bearing rocks. We have seen specimens from Switzerland, Japan, Mexico, and Arizona, as well as Georgia, Illinois, North Carolina, and Tennessee. The species has also been recorded from Central and South America, the Azores, and many parts of Asia and Asia Minor.

Zygodon viridissimus (Dicks.) Brid. Luce Co.–On bark of sugar maple, Upper Falls of the Tahquamenon River, *L. E. Anderson 20052,* Aug. 8, 1967 (MICH). Presque Isle Co.–On elm in hardwood swamp near Clinton Lake, *L. E. Anderson & H. Crum,* July 1967 (MICH).–Widespread in Europe, Washington to California, Mexico, and eastern North America from Maine to North Carolina, this species is decidedly disjunct in northern Michigan.

HEPATICAE

Scapania saxicola Schust. Alger Co.–Growing with *Anthelia juratzkana, Solenostoma sphaerocarpum, Mielichhoferia mielichhoferi,* and *Primula mistassinica* over face of damp, north-facing sandstone cliff above Lake Superior, Pictured Rocks, east of Miner's Castle, *N. G. Miller 4384,* Aug. 6, 1967 (MSC).–This diminutive liverwort was easily spotted in the field because of abundant dark-red gemmae at the tips of both dorsal and ventral leaf lobes. The gemmae of *Scapania glaucocephala,* perhaps the closest relative of *S. saxicola,* are, by contrast, distinctly brownish. Dr. R. M. Schuster has kindly confirmed the identification of this new state record; the species is otherwise known only from Wisconsin and Minnesota.

DISTRIBUTIONAL HISTORY OF *BUTOMUS UMBELLATUS* (FLOWERING-RUSH) IN THE WESTERN LAKE ERIE AND LAKE ST. CLAIR REGION [1]

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Introduced marsh and aquatic flowering plants in North America present challenging subjects for plant ecologists and phytogeographers, particularly if there is an attempt to discover the probable distributional history of these plants. In eastern North America, *Butomus umbellatus* L., the flowering-rush (fig. 1), is becoming a classic example of an introduced species with a documented record of its occurrence and time of spread. Earl L. Core (1941) summarized the distributional history of *B. umbellatus* in North America. The species is introduced from Europe where the plants grow in marshes and along borders of streams and lakes from Italy northward to Norway. In North America it was first observed about 1897 along the St. Lawrence River in Quebec where the first specimens were obtained in 1905. Core cited and mapped the subsequent collection records for the St. Lawrence River, northern New York and Vermont, and

[1]Contribution from the Faculty of Organismic and Developmental Biology, The Ohio State University.

the western end of Lake Erie. Core's paper can give the impression that the species has spread southwestward into Lake Erie from the St. Lawrence River valley. However, after a reinvestigation and examination of the distributional data from *B. umbellatus* in Lake Erie and adjacent areas, I would like to suggest an alternative view.

Core points out that in 1930 Oliver A. Farwell collected *B. umbellatus* in Brownstown township and at River Rouge along the Detroit River in Wayne County, Michigan. These are the oldest specimen records for the Lake Erie region. Farwell (1938) wrote: "This species has long been naturalized in the vicinity of Detroit and southward. I am informed on good authority that it was well established before the present century and that it covered acres of marshes at River Rouge before the operations of the Ford Motor Co. in this region reclaimed the marshland and destroyed the better part of the stand." On his specimen from River Rouge (*O. A. Farwell 8759,* MICH) he wrote, "Has been here since before 1918!!!" According to Gaiser (1949) Farwell's specimen *8742* (GH) bears the note, "In 1918 it covered acres of land in River Rouge that have

Fig. 1. *Butomus umbellatus* L. (Flowering-Rush) at Winous Point, Sandusky Bay, Ottawa County, Ohio. Photographed July 1966 by Richard M. Lowden.

since been filled in." Farwell (1938) went on to say, "There is nothing to prove or disprove the belief that the plant was brought over by Cadillac's party more than three centuries ago and that it has been here ever since." From the rapidity with which *B. umbellatus* has spread in the St. Lawrence River valley since 1900, we can infer that if the species had been in the Detroit River 300+ years ago, it would probably have had a wide distribution in the Lake Erie region before the beginning of the twentieth century. It may have been for this reason that Marie-Victorin (1939) did not accept Farwell's undocumented statement. Marie-Victorin (1938, p. 556-557) continued to suggest the St. Lawrence River as the site of the original or earliest introduction; from there *B. umbellatus* entered the "Great Lakes by way of Lake Erie." However, Farwell's statement that the species was in the River Rouge marshes before 1918 bears further consideration. In fact it is more plausible that the River Rouge locality represents a second separate introduction of *B. umbellatus* in North America, but not one three centuries old. There are no known stations for the flowering-rush between the St. Lawrence River and the Detroit River during the period 1895 and 1918. Gaiser (1949) and Witmer (1964), both of whom reviewed the records of the total known distribution of *B. umbellatus* in North America, gave no information on its occurrence along Lake Ontario. The earliest records reported by Gaiser (1949) for the eastern end of Lake Erie are 22 July 1941, from Erie County, Pennsylvania (*Miss M. C. Wright s.n.*, CM), and 17 August 1948, from Welland County, Ontario (*B. Miller s.n.*, MCM[2]). However, by 1956 flowering-rush was known from several additional stations about the Canadian eastern end of Lake Erie, as well as from five locations on the north side of Lake Ontario as mapped by Montgomery (1956).

If we take Farwell's date of before 1918 as the earliest record for the occurrence of flowering-rush in the River Rouge area, we can trace its distribution throughout the western end of Lake Erie and perhaps into Lake St. Clair (fig. 2). From the River Rouge locality, *B. umbellatus* apparently spread southward along the Detroit River by the early 1930's and into Lake Erie by 1932 where it was first found at Little Cedar Point near Toledo (Lucas County, Ohio). It reached the larger United States islands in western Lake Erie by 1936, Kingsville on the north shore of the lake by 1944, East Harbor (Ottawa County, Ohio) by 1946, and the north shore of Pelee Island by 1948. In recent years the species has been spreading in western Lake Erie about Sandusky Bay, along mouths of rivers, and inland in marshy roadside ditches which are generally from one to two miles from the lake shore. The species reached the east shore of Lake St. Clair by 1934. An interpretation of an independent distributional history of *B. umbellatus* at the western end of Lake Erie and Lake St. Clair appears more plausible than an interpretation which brings the species from the St. Lawrence

[2]In 1963, the herbarium of McMaster University (MCM), aside from a teaching collection, was transfered to the Royal Botanical Gardens, Herbarium (HAM), Hamilton, Ontario, Canada (J. S. Pringle. The Gard. Bull. Royal Bot. Gard. 21(3): 9-24. 1967). However, Miller's specimen is not among the *B. umbellatus* holdings at HAM today, nor is it in the teaching herbarium at MCM (*fide* J. S. Pringle, *in litt.*, 18 March 1968).

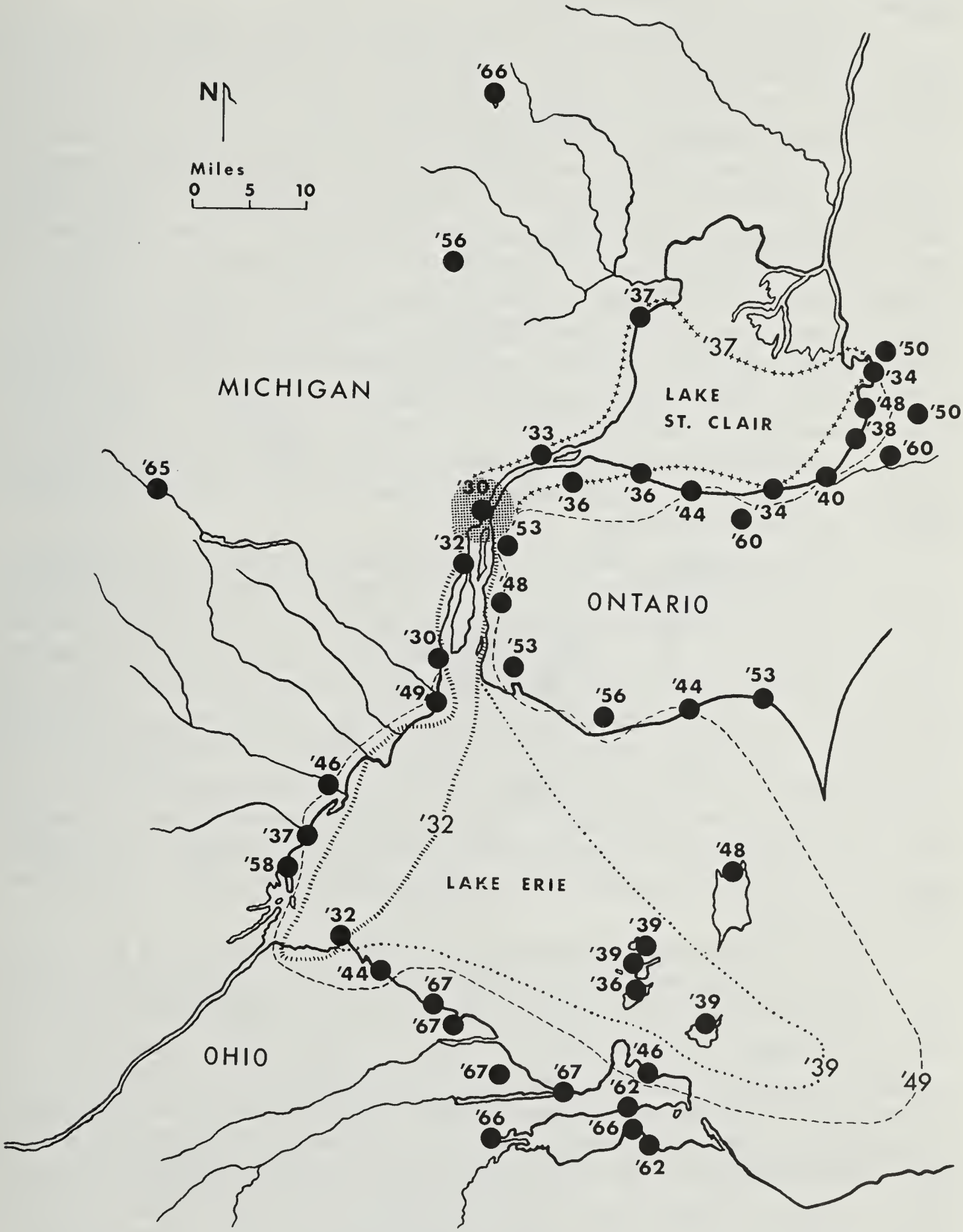

Fig. 2. Known distribution of *Butomus umbellatus* L. in the Detroit River, Lake St. Clair, and western end of Lake Erie based on herbarium specimens cited in this paper, in Core (1941), and in Gaiser (1949). Each date represents the oldest known collection from that locality. The stippled circle represents the locality for the 1918 occurrence reported by Farwell. The dashed and dotted lines enclose approximate areas of the plants' spread by the date indicated.

River across Lake Ontario, Niagara Falls, and eastern Lake Erie, as might be implied by some of the earlier literature.

The idea that the spread of *B. umbellatus* in western Lake Erie has come from a single introduction at River Rouge and from later established colonies is perhaps here emphasized too strongly. Our information, based primarily on data from herbarium specimens, is far from complete. We do not know how many of the plant-records within the Lake Erie-Lake St. Clair region themselves represent separate introductions or escapes from cultivation. According to Gaiser (1949) there are apparently several undocumented accounts as to how and when the plants arrived on the east side of Lake St. Clair. One hypothesis is introduction by seed purchased at Toledo. It therefore may not be necessary to explain a natural migration across this lake. The records cited from Washtenaw and Oakland Counties, Michigan, probably represent escapes from cultivation unrelated to the species' spread about the shores of Lake Erie and Lake St. Clair. Furthermore, flowering-rush probably has been in certain locations long before anyone obtained a voucher herbarium specimen. Even today there are certain additional, perhaps long-occupied, stations which botanists have not visited when flowering-rush plants were blooming.

The mechanisms by which *B. umbellatus* spreads under natural conditions present an intriguing problem about which we have little documentation. Ridley (1930, p. 232-233) summarized previous observations and reported that the seeds generally float for one day after falling from the plant. If they become overgrown with mycelium, they float a fortnight. The seeds may also drift along the bottom of a river in silt, or the seedlings may float in the spring. In the Lake Erie-Lake St. Clair region, the seeds, rootstalks, and bulblets doubtless have been moved around by water currents. Marie-Victorin (1938) emphasized the production of numerous pea-sized bulblets as a means of dispersal in the St. Lawrence River. Wild animals, such as muskrats, may also aid in the dispersal of *B. umbellatus* (Gaiser, 1949). The plant's dispersal mechanisms bear further critical observation and study.

While studying the flora about the southwestern end of Lake Erie during the summers of 1966 and 1967, I obtained additional records for the occurrence of *B. umbellatus.* Since Core's study (1941), this species has spread about Sandusky Bay where it is now known to occur on both sides of the Bay in the roadside ditches at both the new and old Bay Bridges and in the marshes at Winous Point at the head of Sandusky Bay. A few plants were found in ponds and marshes behind the low sandy beach on the shore of Lake Erie at the east edge of Port Clinton and at Magee Marsh (Crane Creek State Park) in the southwestern corner of Lucas County. In several places the marshy ditches along state route 2 from Port Clinton westward in Ottawa County contain numerous plants. However, plants were not found at the Touissant Creek Wildlife Area (SE ¼ Sec. 8, T1N, R15E, Carroll Twp., Ottawa Co.) about 4.5 miles north of Oak Harbor on state route 19, nor were any plants found at the Resthaven Wildlife Area (Castalia Prairie), an extensive tract of marshes, ditches, and shallow ponds to the north and west of Castalia, Erie County. These two localities have been visited and studied frequently by me and/or by field botany classes from The Stone Laboratory. The flowering-rush is known from locations one and one-half

Fig. 3. Map of the Bass Island region in western Lake Erie showing locations where *Butomus umbellatus* L. was observed during the summer of 1967. Solid ovals are at locations where flowering specimens were found; diamonds are at locations for f. *vallisneriifolius*; open ovals are at locations where flowering rush was sought but not found. Place names and localities are shown on the map by numbers as listed below.

1 Alligator Bar
2 Airport Point
3 Ballast Island
4 Buckeye Island
5 East Point
6 Fisher's Pond
7 Fishery Bay
8 Fox's Marsh
9 Gibraltar Island
10 Green Island
11 Haunck's Pond
12 Honey Point
13 Lighthouse Point
14 Middle Bass Island
15 Monument Bay
16 North Bass Island
17 Peach Point
18 Perry's Monument
19 Put-in-Bay
20 Rattlesnake Island
21 Smith's Pond
22 South Dock
23 Squaw Harbor
24 Starve Island
25 South Bass Island
26 Sugar Island
27 Terwilliger's Pond

miles from the former locality (*Stuckey 4624*) and three and one-half miles from the latter locality (*Stuckey 3129*). The species has not been observed in the Portage River west of Oak Harbor to New Rochester or in the Maumee River southwest of Maumee to the Indiana state line. Field studies have not been conducted along these two rivers below these two towns. On the Erie Islands, *B. umbellatus* has not been discovered at several suitable but intensively studied sites (fig. 3), such as Terwilliger's Pond and Squaw Harbor on South Bass Island, Haunck's Pond (Wood, 1966) and Fisher's Pond on Middle Bass Island, the upper end of Fox's Marsh on North Bass Island, and the east shore of Fox's Pond at the south end of Pelee Island.

The sterile underwater form with long limp leaves (*B. umbellatus* L. f. *vallisneriifolius* (Sagorski) Gluck) was not reported from the Erie Islands by Core (1941), but it was mentioned by Gaiser (1949) who quoted a communication from Professor Jacob Verduin stating that such a colony occurred at Alligator Bar, Gibraltar Island. During my survey of the aquatic plants of the Erie Islands in the summer of 1967, several locations for forma *vallisneriifolius* were discovered. The plants generally grew in quiet water from one to two feet deep along the gravelly or rocky dolomite shores. The locations of this underwater form are mapped in figure 3.

The following specimen records further document the distribution of *B. umbellatus* for the western Lake Erie-Lake St. Clair region in addition to those cited in Core (1941) and Gaiser (1949).

MICHIGAN: MACOMB CO.: Marshes along Lake St. Clair, Jul 1937, *Bingham s.n.* (BLH); 3 mi s e of Mt. Clemens, 17 Sep 1950, *Rogers 7287* (ALBC, BLH, MSC, WUD). MONROE CO.: Lake Erie beach, Erie Twp., 14 Sep 1937, *Campbell s.n.* (MICH); Raisin River near Monroe, 17 Aug 1946, *Thompson 5-296* (BLH); barrier beach, muck soil, Pointe Mouillee State Game Area, 16 Jul 1949, *McDonald 5173* (MSC); marsh, floating bog, same locality, 10 Aug 1949, *McDonald 5364* (MICH); wet, lakeshore marsh, Sec. 14, T8S, R8E, 12 Jul 1958, *Hiltunen & Hayes 1512* (WUD); local, edge of drying swale, (land fill) with Typha, etc., s side of Raisin River near its mouth, Monroe, 29 Sep 1962, *Voss 11030* (MICH, MSC). OAKLAND CO.: Edge of lagoon, Cranbrook Estate, Bloomfield Twp., 26 Jun 1956, *Hall s.n.* (BLH); scattered along the shore in shallow water up to 6'' deep, Lakeville Lake, in the small cove adjacent to the Department of Conservation fishing site, 24 Jul 1966, *Mazzer 4104* (MICH). WASHTENAW CO.: One plant seen in flower, SW ¼ Sec. 26, T2S, R6E, Ann Arbor Twp., at e edge of Ann Arbor at Geddes Pond along Huron River, 16 Jun 1965, *Stuckey 2665* (MICH). WAYNE CO.: "Abundant," edge of water, bank of the Detroit River, Wyandotte, 29 Jun 1932, *Grassl 5110* (BLH, DAO, MICH); Detroit, Jul 1933, *Ackley s.n.* (MICH); roadside ditch, Pointe Mouillee State Game Area, 13 Sep 1949, *McDonald 5643* (MSC); a "wet prairie," wet heavy clayey soil, at the intersection of Campau & Pt. Mouillee Rds. near Pt. Mouillee Game Reserve, 1 Sep 1951, *Hall 1371* (BLH).

OHIO: ERIE CO.: Marsh at Carp Pond, Kelleys Island, 7 Jul 1960, *Secoy 135* (OS); roadside ditch, route 2, 2 mi n w of Venice, Margaretta Twp., 18 Aug 1962, *E. M. Herrick s.n.* (OS); locally abundant in shallow water or muddy bottom of Carp Pond, north-central shore of Kelleys Island, 30 Jun 1966, *Stuckey 2973* (OS); local in marsh along Sandusky Bay at e end of new bridge, Margaretta Twp., at the s city limits of Bay View, 27 Jul 1966, *Stuckey 3129* (SMU); common in roadside ditch along state route 269, Margaretta Twp., ca. ½ mi e of the town of Baybridge, 8 Jul 1967, *Stuckey 4262* (OS); common in wet soil throughout lower portions of Carp Pond, north-central shore of Kelleys Island, 15 Jul 1967, *Stuckey 4416* (OS). LUCAS CO.: Mud flats at Reno Beach, 5 Sep 1944, *Bartley s.n.* (OS); a few plants in marsh behind low sandy beach at Magee Marsh (Crane Creek State Park), Sec.

12 s e corner of Jerusalem Twp., 21 Aug 1967, *Stuckey 5305* (OS). OTTAWA CO.: Hatchery Bay [Fishery Bay], South Bass Island, 20 Aug 1936, *Tiffany s.n.* (OS) [First known specimen record for the Erie Islands, but not cited by Core (1941)]; edge of water, route 2 at route 240 at n end of Bay Bridge, Danbury Twp., 18 Aug 1962, *E. M. Herrick s.n.* (OS); occasional and scattered in wet depression near dikes at Winous Point, w end of Sandusky Bay, Bay Twp., ca. 4 mi s w of Port Clinton, 22 Jun 1966, *Stuckey 2940* (FTSL); Honey Point, North Bass Island, 5 Jul 1965, *D. Albright 47* (OS); a few plants along gravel shore at South Dock, s shore of North Bass Island, 4 Jul 1967, *4182*; occasional in shallow water at Smith's Pond, s e corner of North Bass Island, 4 Jul 1967, *4186*; one small colony in roadside ditch near Sandusky Bay, along old state route 2 just n of new Bay Bridge, s w corner of Danbury Twp., ca. 1 mi e of Gypsum, 8 Jul 1967, *4260*; occasional on thin, wet soil over dolomite rock at Airport Point (opposite Starve Island) s e shore of South Bass Island, 13 Jul 1967, *4350*; common in roadside marsh along causeway in East Harbor State Park at East Harbor, n side of Danbury Twp., 14 Jul 1967, *4430*; a few plants in shallow water of pond behind low sandy beach at w edge of Lakeview Park at e edge of Port Clinton, Portage Twp., 19 Jul 1967, *4498*; common in roadside ditch along state route 2, SE ¼ Sec. 19, T7N, R16E, Erie Twp., ca. 2 mi n of Lacarne, 24 Jul 1967, *4593*; occasional in roadside ditch along state route 2, SW ¼ Sec. 32, T8N, R15E, Carroll Twp., ca. 6 mi n of Oak Harbor, 24 Jul 1967, *4624*, all *R. L. Stuckey* (OS).

ONTARIO: ESSEX CO.: Shore of river, Puce, 25 Jul 1936, *Rabl s.n.* (TRT); Windsor, 14 Aug 1936, *Brown s.n.* (TRT); swamp, at 2 sites, from 15 to 20 plants were observed, Canard River, 4 mi n of Amherstburg, 23 Jul 1948, *Frankton et al.* 713 (DAO); marshy field at mouth of Sturgeon Creek, Loc. 74, Mersea Twp., 3 mi s e of Leamington, 18 Jun 1953, *Shields 1330* (HAM, TRT). marshy field near mouth of Big Creek, #82, Conc. II, Malden Twp., 4¾ mi s e Amherstburg, 29 Jun 1953, *Shields 1461* (TRT); on Hy no. 18, 1½ mi e of La Salle, 21 Jul 1953, *Montgomery & Shumovich 828* (OAC); on no. 18 highway, Linden Beach, 16 Sep 1953, *Montgomery & Shumovich 942* (OAC); edge of canal, near Thames R. lighthouse, 16 Sep 1953, *Montgomery & Shumovich 962* (OAC); on Hy #18, 2 mi s of Amherstburg, 16 Sep 1953, *Montgomery & Shumovich 952* (OAC); no. 18 highway at Cedar Beach, 16 Sep 1953, *Montgomery & Shumovich 943* (OAC); in ditch near edge of creek #424, Sturgeon Creek about 3 mi s e of Leamington, 23 Jun 1954, *Soper 5996* (TRT); on Hy no. 18, 1½ mi e of Oxley at creek, 16 Sep 1956, *Montgomery & Shumovich 946* (OAC); common along river shore, Ruscom River, Rochester Twp., 8 Aug 1962, *Bassett & Koyama 4240* (DAO). KENT CO.: Plentiful, ditch leading into dredge cut, Mitchell's Bay, Lake St. Clair, 12 Jun 1936, *Doan s.n.* (TRT); shallow water at edge of cattail marsh, Dover Twp., Mitchell's Bay, 7 Aug 1947, *Cook 137* (UWO); 2 ft water, Lot 1, Conc. VIII, Dover Twp., 25 Jul 1948, *Soper & Dale 4061* (DAO, TRT); wet ditch, Paincourt to Mitchell Bay, 10 Jul 1950, *J. F. Clavert 61a* (HAM); in shallow water at edge of ditch, Lot 9, Conc. XII, Dover Twp., along ditch 1 mi s w of Mitchell Bay, 14 Aug 1950, *Shields 314* (CAN, HAM, TRT); in shallow water at edge of creek, Lot 13, Conc. XIV, Dover Twp., #29a, Rankin Creek ca. 1¼ mi n of Mitchell Bay, 17 Aug 1950, *Shields 352* (TRT); in shallow water near mouth of creek, #29b, Rankin Creek, ca. 1¼ mi n of Mitchell Bay, 18 Aug 1950, *Shields 364* (TRT); common in water-filled roadside ditches to Lake St. Clair, 8 mi w of Chatham, 14 Jul 1960, *Mulligan & Frankton 2479* (DAO).

The following collections of *B. umbellatus* L. f. *vallisneriifolius* (Sagorski) Gluck were taken during the summer of 1967 by the author. Specimens are in The Ohio State University Herbarium (OS) and duplicates are elsewhere as noted.

Buckeye Island: Occasional in water about 1 foot deep over dolomite rock, n side of the island, 29 Jun, *4128*; occasional in water about 1 foot deep over dolomite rock, s side of the island, 29 Jun, *4183*.

North Bass Island: Occasional in water about 1½ feet deep along s shore of the island, about half way between South Dock and Honey Point, 1 Aug, *4757*.

South Bass Island: One small colony in about 2 feet of water in Fishery Bay at Peach Point, 24 Jun, *4091* (MICH, SMU); occasional in water about 2 feet deep just w of Perry's Monument in Monument Bay, 11 Jul, *4297*; locally common in quiet water about 1 foot deep, n e corner of Monument Bay along n w shore of the island, 11 Jul, *4302;* locally common in quiet water about 1 foot deep over dolomite rock along s shore, ca. 1½ mi from Lighthouse Point, 13 Jul, *4343*; occasional in water about 1 foot deep along dolomite shore, s e side of East Point, ca. ¼ mi s of Buckeye Island, 11 Aug, *4963*.

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Herbarium specimens cited have been compiled from (1) The Michigan Flora Project records in the University of Michigan Herbarium, Ann Arbor (including data from specimens at ALBC, BLH, MICH, MSC, and WUD), (2) specimens in The Ohio State University Herbarium (OS) and the herbarium at The Franz Theodore Stone Laboratory (FTSL), and (3) information supplied from the Royal Botanical Gardens Herbarium (HAM), Hamilton, Ontario, by Dr. James S. Pringle, from the National Museum of Canada (CAN), Ottawa, Ontario, by Dr. James H. Soper, from the Research Branch of the Canada Department of Agriculture (DAO), Ottawa, Ontario, by Dr. William J. Cody, and from the University of Toronto (TRT), Ontario, by Dr. James E. Cruise. I have examined all cited specimens at FTSL, MICH, and OS.

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THE CANTHARELLACEAE OF MICHIGAN

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The Cantharellaceae have been studied in some detail in recent years (Corner, 1966; Petersen, 1968, in press) but many problems are still unsolved and much difference of opinion remains to be resolved. The family as I recognize it consists of fungi with basidiocarps essentially trumpet-shaped to vase-shaped or with the pileus, if one can be said to be present, lobed and/or lopsided in its development. If the last mentioned condition prevails the basidiocarps are often found in a compound cluster. The hymenophore may be the smooth under-surface of the pileus, or this surface may be variously wrinkled to vein-like from radially arranged folds or wrinkles, or it may be in the form of fold-like lamellae often with numerous cross veins. The spores may be white to buff or pinkish in deposit and smooth to slightly ornamented. The pigment may be either in the wall or the cell content. Depending on the species, spore shape varies from globose to nearly oblong. In some the wall stains blue in cotton blue–lactic acid medium following heating, and this dye often causes the ornamentation, if such is present, to stand out rather clearly. Cystidia are rare in the family but known for some American species (see Petersen, 1968, in press). The hymenophoral trama is of loosely interwoven hyphae and hence unspecialized, as one would expect in view of the configuration of the hymenophore. The pileus trama is also typically unspecialized as to type especially in the cuticular region.

In the study presented here I have made an effort to be sure that all the features emphasized in the descriptions were found on a single collection or even on a single basidiocarp in order to avoid confusing similar-appearing taxa. This procedure of course cannot be applied absolutely, especially where ranges of size are concerned, but it does furnish a valid point for an interpretation of diversity in the family. Wells and Kempton (1968) found this method very useful in *Clavariadelphus,* and it has been found to be effective in the three genera treated here.

The major characters of value in taxonomy, as it now appears, are the color of the spore deposit, presence or absence of clamp connections, configuration of the hymenophore, solid versus hollow stipe, spore ornamentation, and location of pigments. Using these features, along with the pigmentation of the basidiocarp generally, brings out certain interesting points relative to the evolution of the group.

First, a white spored "line" of species can be traced from *Clavariadelphus* to both *Craterellus* and *Cantharellus* and along with it we find increasing complexity in the configuration of the hymenophore. Secondly, an almost exactly parallel series can be arranged leading into both genera for the species with colored spores, only here in *Craterellus* it seems to end in species like *C. fallax* with practically smooth hymenium whereas in *Cantharellus* the line with colored

spores ends (as far as the family is concerned) in taxa which have fairly well-formed gills, some with acute edges at maturity. The white-spored line at present appears to connect readily with the Hygrophoraceae, which family features a waxy hymenophore with thick gills and relatively long basidia. The line with colored spores connects, though not as smoothly, with the genus *Clitocybe* sensu lato of the Tricholomataceae of the Agaricales. The possibility of *Gomphus* connecting up to *Scutiger* in the Polyporaceae should be carefully explored since here is a true tendency for the production of wide pores and rather firm context of the basidiocarp (see *G. kauffmanii*).

I regard the family as primitive among the fleshy fungi largely because of the relatively simple basiciocarps, the long basidia, and the facts that the latter often bear more than four spores and that occasionally one observes lateral sterigmata on basidia in some species.

Much more work needs to be done on the North American species, but it is pointless to study herbarium specimens for which essential data are lacking, because correlations of macroscopic and microscopic features cannot be made accurately. The present account is given to place my own observations on record in the hope they will serve as a guide to, and also facilitate, future work.

The color terms in quotation marks are from R. Ridgeway, *Color Standards and Color Nomenclature* (Washington, D. C., 1912). The specimens cited are deposited in the Herbarium of the University of Michigan.

The field work has been carried out over the years since 1933 with financial aid from the University of Michigan Herbarium, from E. B. Mains (now retired), from the Faculty Research Fund of the University of Michigan, and from personal contributions.

Key to Genera

1. Hymenium vein-like to merulioid (of wide shallow pores) *and* spore wall faintly colored buff to slightly browner (as seen under a microscope) . . . . . *Gomphus*
1. Hymenium smooth to vein-like or obtusely folded radially into rudimentary lamellae (with or without cross veins); spores if colored with the pigment in the protoplasm 2
   2. Clamp connections absent; basidiocarps typically dark colored; hymenium smooth to radially wrinkled or vein-like . . . . . *Craterellus*
   2. Clamp connections present; hymenium typically yellowish or orange and smooth to lamellate 3
3. Basidiocarps cylindric to clavate, lacking a pileus (but almost pileate in *C. truncatus*); hymenium smooth or wrinkled . . . . . *Clavariadelphus*[1]
3. Basidiocarps pileate and hymenophore usually more or less lamellate (nearly smooth in some bright colored species) . . . . . *Cantharellus*

GOMPHUS S. F. Gray, Nat. Arr. Brit. Pl. 1: 638, 1821.

Basidiocarps fleshy, when young truncate-clavate with an even margin at first but growing out irregularly to produce a lobed and wavy pileus which may be lopsided or vase-shaped; pigmentation various; hymenophore varying from smooth to radially wrinkled to merulioid with the depressions broad and shal-

[1] See Wells & Kempton (1968) for a treatment of the North American species.

low or in extreme cases with poorly defined pores; spore wall slightly colored as seen in groups of spores under the microscope.

Type species: *Gomphus clavatus*

Key to Species

1. Basidiocarps with dark colors dominant; hymenophore cinereous to violaceous-drab or violet-brown 2
1. Basidiocarps with bright colors; hyenophore pallid, yellowish or pale orange 3
   2. Spores roughened; clamp connections present . . . . . 1. *G. clavatus*
   2. Spores smooth; clamps absent . . . . . 2. *G. pseudoclavatus*
3. Pileus floccose-squamulose; typically solitary to gregarious . . . . . 3. *G. floccosus*
3. Pileus coarsely squamose and in large fruitings many of the basidiocarps compound (merismoid) . . . . . 4. *G. bonari*

SECTION GOMPHUS

Basidiocarps with somber colors and hymenophore mostly as radial wrinkles and veins often forming late and mostly near the pileus margin.

1. *Gomphus clavatus* (Fr.) S. F. Gray, Nat. Arr. Brit. Pl. 1: 638. 1821.

Cantharellus clavatus Fries, Syst. Myc. 1: 322. 1821.

Figs. 1-3.

Pileus 3.5-10 (15) cm broad, at first scarcely differentiated from the stipe (the basidiocarps resembling those of *Clavariadelphus truncatus* in shape), soon the margin growing outward irregularly to produce a lobed to lopsided structure, finally irregularly funnel-shaped as the margin becomes uplifted; surface dry and glabrous, unpolished to velvety, in age at times minutely scaly; color at first dull vinaceous to purplish but fading to sordid brown to dingy alutaceous ("dark purple-drab" when young, soon fading through "light russet-vinaceous," "russet-vinaceous," avellaneous, or finally "clay-color" to "tawny olive"—dingy yellow-brown). Context thick in the disc, thinner (about 5 mm) in the extended margin, whitish to pale buff ("cinnamon-buff"); odor and taste not distinctive.

Hymenophore in the form of numerous low crowded frequently forked or anastomosing ridges and with thick veins connecting the ridges, at times almost poroid in appearance, decurrent almost to the base of the stipe, color purple to purple-vinaceous fading to avellaneous or more vinaceous and when dusted with spores with an ochraceous overtone.

Stipe 4-10 cm long, 8-30 mm thick below, frequently compound and expanding upward into the pileus, sometimes many fused at the base into a fleshy mass, solid, finally hollowed somewhat, purple-drab to avellaneous or dingy alutaceous above, whitish below from a thin coating of mycelium.

Spore deposit pale alutaceous; spores 10-13 x 5-6.5 μ narrowly ellipsoid to narrowly ovoid, the outer wall warty to wrinkled, nearly hyaline in KOH, pale dingy tawny in Melzer's but soon merely pale ochraceous; in profile usually with a distinct suprahilar depression.

Basidia 4- to 6-spored, 60-80 (90) x 7-9 μ, narrowly clavate, hymenium dull orange-brown when revived in KOH, orange-yellow in Melzer's. Cystidia none. Filamentous elements present in hymenium and 3-4.5 μ wide (possibly young basidia?).

Gill trama with an interwoven central strand which is merely a slight extension of the context of the pileus, the subhymenial zone yellowish in KOH but fading, hymenopodial region only slightly more loosely floccose than the central strand. Context of pileus of compactly interwoven thin-walled, smooth hyaline hyphae 4-10 μ in diam., and the cells mostly uninflated; epicutis of pileus of upright filaments (a trichodermium) 40-80 x 2.5-6 μ, brownish in mass when revived in KOH but soon hyaline and hyaline when isolated under the microscope, forming a very compact turf. Clamp connections regularly present at the septa.

Habit, habitat, and distribution: Scattered, gregarious or cespitose, often in arcs or rings, common in cold wet conifer forests in the fall in the Upper Peninsula, not as abundant in the Lower Peninsula. We have one record of the species from an elm-soft maple swamp at Sharon Hollow, Washtenaw Co. (Smith 62896); late summer and fall.

Observations: Further studies of Smith 62896 from the same locality are needed as the basidiocarps were old when found. The rough spores and clamps, however, exclude *C. pseudoclavatus* which is the species it was mistaken for when collected. *C. clavatus* is a choice edible species in spite of its appearance. The basidiocarps soon become riddled with larvae, however, so they should be sorted when collected. Discard those with "pin-holes" in the flesh.

2. *Gomphus pseudoclavatus* (Smith) Corner, Monogr. Cantharelloid Fungi, p. 124. 1966.

Cantharellus pseudoclavatus Smith, Mycologia 39:505. 1947.

Pileus 3-8 (10) cm broad, truncate, the margin soon growing out and becoming spreading to uplifted, often developing on one side only, pileus finally flabelliform to funnel-shaped, the margin usually very wavy and lobed in age, surface dry and unpolished or in age appressed fibrillose with the fibrils arranged in fascicles at times, color near "vinaceous-buff," "cinnamon-buff," or "avellaneous" (pale alutaceous to grayish) when young, often a purplish tint pervading along the margin, finally sordid alutaceous and remaining this color in drying or becoming drab. Context thick in the disc but thin in the extended margin, white to whitish; odor mild, taste slightly fungoid.

Hymenophore variable in form and color, more or less in the form of fold-like gills moderately close to subdistant, decurrent, narrow, and connected by numerous cross veins to such an extent as to give a shallowly poroid appearance, purplish vinaceous at first, with an ochraceous sheen as spores mature.

Stipe 2-6 cm long, 1-2 cm thick at apex, solid at first, pallid within, enlarged upward, surface colored more or less like the pileus, unpolished to tomentose, base white mycelioid.

Spore deposit pale ochraceous; spores 9-12 x 5-6.5 μ, ovate to ellipsoid, smooth, thin-walled, pale yellow in Melzer's, nearly hyaline in KOH.

Basidia 50-80 x 9-11 (12) μ, 4- to 8-spored, typically flexuous, when revived in KOH the sections appearing pale bister, individual basidia nearly hyaline but with a highly refractive amorphous content. Cystidia none.

Subhymenium with elements approximately parallel to the basidia but more interwoven as the loosely interwoven hymenopodial zone is approached, hymenopodium of loosely interwoven hyphae; central strand of compactly interwoven hyphae, pale bister in Melzer's. Pileus with epicuticular hyphae hyaline in KOH, appressed and 3-6 μ diam. Pileus context of hyphae similar to those of epicutis or somewhat broader (4-9 μ diam.), rather compactly interwoven, smooth and thin-walled. Clamp connections absent.

Habit, habitat, and distribution: Cespitose-gregarious in oak-hickory woods after heavy rains in late summer, rare. Known to date from Washtenaw County, Michigan, and northern California.

Observations: In the field this species is easily mistaken for *G. clavatus* but the smooth spores and lack of clamps at once distinguish it. It has a fleshy carpophore and when immature it reminds one of *Clavariadelphus truncatus.* Hence it appears to be properly placed in *Gomphus.* It is a much thicker fleshier fungus than *Cantharellus sinuosus* Fries, if one judges it by the Friesian descriptions. To my knowledge the edibility of *G. pseudoclavatus* has not been tested, but it would indeed be a surprise if the species were poisonous.

Section EXCAVATUS (Smith & Morse) Corner,
Monogr. Cantharelloid Fungi, p. 113. 1966.

Cantharellus section *Excavatus* Smith & Morse, Mycologia 39:500. 1947.
Turbinellus Earle, Bull. N. Y. Bot. Gard. 5: 407. 1909.

Type species: *Gomphus floccosus*

3. *Gomphus floccosus* (Schw.) Singer, Lloydia 8: 140. 1945.

Cantharellus floccosus Schweinitz, Trans. Am. Philos. Soc. 4: 153. 1832.

Fig. 4.

Pileus 5-10 (15) cm broad, basidiocarp 8-20 cm high, truncate when young, soon becoming hollowed in the center from the breaking up of the tissue into floccose scales, the margin ascending at first but finally spreading and then the pileus trumpet-shaped, the interior (upper) surface innately scaly with the scales appressed toward the margin, more recurved in the tube and orange to reddish orange but finally yellow, the spaces between also orange to yellow. Context moderately thick, thin in old pilei, white or pallid, unchanging, fibrous; odor and taste not distinctive.

Hymenophore with fold-like ridges which frequently fork or anastomose, in age the configuration merulioid, decurrent almost to the base of the stipe in an irregular manner, pale buff to more yellowish.

Stipe short and not sharply distinct from the pileus, solid at first but becoming hollow from the apex down as the cavity forms in the pileus, surface whitish and unpolished, tapered to the base which is usually deeply sunken in the humus.

Spore deposit ochraceous; spores 12-15 x 6-7.5 μ, outer wall slightly wrinkled, wall slightly yellowish in KOH, in Melzer's ochraceous tawny, in face view narrowly elliptic, in profile often with a distinct suprahilar depression, slightly yellowish in KOH.

Basidia 52-60 x 10-12 μ, clavate, hyaline in KOH, yellow in Melzer's Cystidia none. Hymenophoral trama interwoven and the hyphae about like those of pileus context and merging with them, hyaline in KOH, yellowish in Melzer's. Clamp connections absent.

Habit, habitat, and distribution: Late summer and fall in cold habitats in the northern part of the state under conifers, rare.

Observations: Some people eat and enjoy this species without suffering distressing after-effects, but others are not so fortunate. Cases of poisoning by it are usually of the mild type: the patient is not ordinarily hospitalized.

4. *Gomphus bonari* (Morse) Singer, Lloydia 8: 140. 1945.

Cantharellus bonari Morse, Mycologia 22: 291. 1930.

Pileus 3-12 cm broad, truncate when young, in age broadly vase-shaped, margin finally spreading and undulating and/or lobed, the disc soon depressed and the surface broken into thick more or less erect scales which fill the central depression, scales orange at the tips blending to lemon-yellow at the base and giving the entire pileus an orange-yellow color, fading in age to pale tan ("pinkish-buff") or becoming this color when dried. Context white, firm, tapering to margin, relatively thin; odor and taste not distinctive.

Lamellae obtuse, very narrow, in the form of radially disposed subdistant decurrent folds or by maturity somewhat merulioid, primary folds decurrent far down the stipe, milk-white when fresh becoming dingy cream-color and when dried pale dingy brownish.

Stipe 2-8 cm long, 10-20 mm thick, solid, glabrous, white, enlarged upward into the pileus, branching (up to 13 pilei seen attached to a common base), many pilei remaining aborted, becoming hollowed from the apex downward.

Spore deposit weakly ochraceous. Spores 10-12 (14) x 5-6 μ, subellipsoid, smooth or outer wall slightly wrinkled, ochraceous tawny in Melzer's, in KOH weakly yellowish.

Basidia 2- to 6-spored, 44-70 x 7-8 μ, narrowly clavate with flexuous pedicels, hyaline in KOH. Cystidia none. Hymenophoral trama of interwoven hyaline hyphae lacking clamp connections. Pileus trama hyaline in KOH, the hyphae similar to those of the hymenophoral trama.

Habit, habitat, and distribution: Not known for certain in the state, but on some occasions clusters of undeveloped strongly scaly basidiocarps arising several on a common stipe have been found. I now suspect these of belonging to this species. Abundant material of this species has been collected in central Idaho.

Observations: In Idaho and Oregon I did not recognize the mature stage of this species but misidentified it with *C. floccosus.* Perhaps the important question to ask is whether or not *G. bonari* is just a scaly merismoid variant of *G. floccosus.* Dr. Ronald Petersen (pers. comm.), however, has found evidence that at least one variant of *G. floccosus* in the southeast can be distinguished, and he has found a significant difference in the spore ornamentation between *G. bonari* and *G. floccosus.* It is likely that much of the northern and western material I have previously placed in *G. floccosus*, is merely the mature stage of *G. borani.*

CRATERELLUS Persoon, Myc. Eur. 2: 4. 1825.

The species I place here generally trend toward dark colors such as date brown, gray, fuscous, or blackish; and clamp connections are absent. The basidiocarp is more funnel-shaped than in *Cantharellus* but this is a relative feature. If the genus can be maintained at all it must be on the absence of clamps combined with the weak development of the hymenophore and the dark colors.

Type species: *C. cornucopioides*

Key to Species

1. Spore deposit salmon-buff . . . . . 10. *C. fallax*
1. Spore print white to dingy ochraceous 2
   2. Spore deposit pale buff . . . . . 9. *C. cornucopioides*
   2. Spore deposit white 3
3. Odor sickening sweetish . . . . . *C. foetidus*
3. Odor fragrant to lacking 4
   4. Hymenophore smooth or practically so; pileus watery brown fresh . . . 5. *C. calyculus*
   4. Hymenophore becoming wrinkled to veined; pileus blackish brown to bluish fuscous moist 5
5. Cuticular hyphae disarticulating . . . . . 6. *C. caeruleofuscus*
5. Cuticular hyphae not disarticulating to an appreciable extent . . . . . 7. *Craterellus cinereus* var. *multiplex*

5. *Craterellus calyculus* (Berk. & Curt.) Burt, Ann. Missouri Bot. Gard. 1: 339. 1914.

Stereum calyculus Berk. et Curt. Jour. Bot. Hooker 1: 238. 1849.
Pseudocraterellus calyculus (Berk. & Curt.) Reid, Persoonia 2: 124. 1962.

Pileus about 1 cm broad, plane with a wavy margin, disc perforated, moist and hygrophanous, watery brownish fading to gray and near avellaneous as dried, when faded the surface uneven to slightly scrupose.

Hymenium smooth to slightly sulcate, drying smooth, gray drying avellaneous (with a tinge of pinkish), decurrent down the upper part of the stipe.

Stipe about 3 cm long and 4 mm at apex, narrowed to 2 mm at base, dingy brownish below, concolorous with hymenium above, apical region cream-buff to pale dingy pinkish-buff as dired.

Spore deposit white (but thin); spores 7-9 x 4.5-5.5 μ, ellipsoid, smooth, hyaline in KOH, yellowish in Melzer's, thin-walled.

Basidia 33-46 x 8-9 μ, relatively short-clavate, 4-, 6- (8-) spored, hyaline to yellowish in both KOH and Melzer's. Cystidia none.

Subhymenium of interwoven hyphae 5-9 μ in diam, and with dingy yellow-brown content, walls thin and smooth. Context hyphae scarcely distinct from those of the subhymenium, content dingy pale yellow in KOH, yellow in Melzer's, the cells uninflated and 5-10 μ in diam., epicutis of pileus merely of compactly interwoven hyphae similar to those of context. Clamp connections absent.

Habit, habitat and distribution: Solitary on a mound of earth formed around an uprooted tree in a beech-maple forest, Garden Peninsula, Mich., Aug. 17, 1961. Smith 63943.

Observations: I use this name provisionally. Both Corner (1966) and Burt (1914) indicate that the spores are colored, and Corner placed the species in *Pseudocraterellus.* A thin deposit of a typically buff-spored species often appears white; hence I hesitate to emphasize the presumed difference. On the other hand the cuticular hyphae did not disarticulate readily in the mounts I made which is against my proposed identification. I simply take this means of placing the data from my collection on record in the hope of stimulating further study on the species involved. It might even be the "true" *C. sinuosus.*

6. *Craterellus caeruleofuscus* sp. nov.

Fig. 5.

Pileus (1) 3-8 cm latus, infundibuliformis, ad marginem lobatus, saepe fimbriatus, caeruleofuscus demum griseobrunneus, glaber, levis vel rugulosus. Contextus tenuis; sapor subamarus; odor nullus. Lamellae venosiformis, confertae, vel subdistantes, furcatae, atrocaeruleae. Stipes 5-8 cm longus, 4-12 mm crassus, cavus, fuscus. Sporae in cumulo albidae, 7-9 x 5-6 μ. Typus: Smith 42484 (MICH).

Pileus (1) 3-8 cm broad, infundibuliform and the hollow extending into the stipe as in *C. fallax,* rarely compound with one pileus forming within another, margin very irregular to lobed or compound-lobed, the extreme edge at times somewhat fimbriate to toothed, more or less "fuscous" when moist (bluish black), fading to wood-brown or avellaneous in the manner of an hygrophaneous species, glabrous, smooth to wrinkled; context thin and membranous, taste disagreeable, odor none.

Lamellae poorly formed, narrow and fold-like, close to subdistant, decurrent, almost vein-like, with much forking and with obtuse edges, in dried specimens mostly disappearing except for near the pileus margin, bluish fuscous and waxy when fresh, fading to a dull wood-brown, in drying becoming ochraceous buff to pale dingy ochraceous or pallid.

Stipe 5-8 cm long, 4-12 mm at apex, equal or narrowed downward, hollow, fuscous or nearly so, hymenium decurrent far down the stipe and the latter smooth in this portion; stipe surface below the hymenium dingy and unpolished, hymenium drying with a dingy ochraceous tone.

Spore deposit white; spores 7-9 x 5-6 μ, in face view elliptic to subovate, in profile obscurely inequilateral to elliptic, thin-walled, smooth, hyaline in KOH and merely yellowish to hyaline in Melzer's.

Basidia mostly 4-spored (rarely 2-spored), 48-60 x 6.5-8 μ, narrowly clavate and flexuous, slightly yellowish in Melzer's, in KOH singly nearly hyaline but sections of the hymenium brownish. Pleurocystidia and cheilocystidia absent.

Subhymenium of closely interwoven pallid brownish (in KOH) hyphae 4-5 μ diam. (almost as broad as the basidia), the hymenopodial zone of very loosely interwoven but somewhat diverging hyphae extending principally from the central strand of the trama to the denser subhymenial area; central strand (where gills are present) a loosely interwoven mass of hyphae similar to those of the subhymenium and hymenopodium, brownish in KOH, the pigment located in the wall. Epicutis of pileus of appressed non-gelatinous hyphae 5-7 μ in diam. with the walls very slightly brownish in KOH (viewed singly) and somewhat enlarged at the septa (to 8 μ in hyphae 6 μ in diam.), hyphae readily breaking at

the septa into units of 2-3 cells long, sparsely branched and frequently septate; hyphae of the context similar to those of the epicutis but more interwoven; clamp connections absent.

Habit, habitat, and distribution: Scattered to gregarious on Sphagnum in bogs, Tahquamenon Falls State Park, September. Smith 42484.

Observations: This is close to *Craterellus sinuosus* Fries, and in fact I would place it there except for the fact that Corner gives the spore print color for that species as pale ochraceous and the spores as 10-13 x 7.5-9 μ; the colors he describes are also different.

7. *Craterellus cinereus* var. *multiplex* (Smith) comb. nov.

Cantharellus cinereus f. *multiplex* Smith, Pap. Mich. Acad. 38: 54. 1953.

Fig. 6.

Basidiocarps compound, 6-10 cm broad, 8-12 cm high, pilei 1-4 cm broad, centrally to laterally stipitate (often merely eccentric), more or less infundibuliform and deeply perforated, glabrous or nearly so, faintly zoned, becoming uneven to somewhat squamulose, the margin pallid and often crenate, central part smoky fuscous to "mummy-brown." Context thin, concolorous with surface; taste slightly disagreeable, odor faint and scarcely distinctive.

Lamellae decurrent, fold-like but becoming more distinctly lamellate by maturity, close to subdistant, edges obtuse, deep cinereous slowly becoming a paler bluish gray.

Stipe compound and variable in width and length but up to 1 cm thick, hollow, surface smooth, grayish, darker in the cortex.

Spore deposit white; spores 8-11 x 5-6 μ, yellowish in Melzer's, elliptic to ovate in face view, in profile elliptic, or the ventral line straighter than the dorsal line (or sometimes a little concave), thin-walled, sterigmal appendage very inconspicuous.

Basidia 4-, 6-, or 8-spored, (45) 60-80 x 9-11 μ, clavate, walls flexuous, in sections orange to reddish in Melzer's, in KOH pale bister to nearly hyaline. Pleurocystidia and cheilocystidia none.

Subhymenium of compactly arranged hyphae more or less parallel to the basidia, brownish in KOH, 3-5 μ diam., hymenopodial area more interwoven but equally as compact as the distinctly interwoven central area which is more or less bister in KOH. Context of pileus bister in KOH in sections but individual hyphae hyaline, thin-walled, equal to slightly inflated and 6-15 μ diam.; epicutis of pileus of compactly interwoven hyphae with some separate filaments projecting or grouped to form fascicles. Clamp connections absent.

Habit, habitat, and distribution: Cespitose on the ground in mixed pine and hardwoods, Colonial Point, Burt Lake, Michigan, Aug. 8, 1951. Smith 37531.

Observations: The gills are finally as well-formed as in *Cantharellus,* which only emphasizes the close relationships among all taxa of this family. We have no information on the edibility of this species.

8. *Craterellus foetidus* sp. nov.

Fig. 7.

Pileus 3-7 cm latus, infundibuliformis, aquose griseus demum cinereus, hygrophanus, subsquamulosus, ad marginem undulatus. Contextus griseus, graveolens, sapor mitis. Lamellae venosae, furcatae, confertae, cinereae, in siccatis subochraceae. Stipes 3-6 cm longus, 1-2.5 cm crassus, cavus, fragilis, cinereus. Sporae in cumulo albidae, 8-10 (11) x 5-6 μ. Fibulae nullae. Typus: Smith 62498 (MICH).

Pileus 3-7 cm broad, infundibuliform to very irregular, the hollow of the funnel continued into the stipe, surface hygrophanous to subhygrophanous, watery gray moist, fading to ashy gray, uneven or near the margin squamulose to almost reticulate, in age the margin sometimes splitting and often quite wavy, color of dried pilei pale drab. Context very fragile, watery gray; taste mild or nearly so, odor sickening sweetish; KOH and $FeSO_4$ no reaction.

Lamellae vein-like to lamellate, narrow, much-branched and anastomosing, close, in age often compound to nearly poroid, glaucous-cinereous to bluish gray, drying pale dull cinnamon.

Stipe 3-6 cm long, 1-2.5 cm at apex, narrowed downward, hollow, fragile, glaucous-cinereous like the gills (where covered by hymenium) but grayer and naked below this line.

Spore deposit white; spores 8-10 (11) x 5-6 μ, ellipsoid, smooth, thin-walled, non-amyloid (yellowish in Melzer's), sterigmal appendage very inconspicuous.

Basidia 50-70 x 8.5-10 μ, clavate, hyaline in KOH, 4-, 6-, and 8-spored, narrowly clavate to flexuous to straight walls. Pleurocystidia and cheilocystidia none. Subhymenium of elements about parallel with the basidia, 4-6 μ diam., septa numerous, more interwoven toward the very loosely interwoven hymenopodial zone; central strand of compactly interwoven hyphae hyaline individually but bister as sections are revived in KOH; hyphae of pileus context 6-14 μ diam., hyaline, thin-walled, smooth, compactly interwoven; epicuticular hyphae more compactly arranged but otherwise similar to those of the context. Clamp connections none.

Habit, habitat and distribution: Cespitose under oak, July 4, 1960, Pinckney Recreation Area, Washtenaw County, Mich. Smith 62498 (type). Also from Burt Lake, Smith 63890 and 63885. Not common.

Observations: The sickening-sweetish odor is a pronounced feature of fresh collections, but is lost in drying. The species is most closely related to *Craterellus cinereus* var. *multiplex* but the colors are different, the odor of fresh material is different, and in *C. foetidus* there is a pronounced tendency of the hymenophore to appear shallowly poroid. The question of whether this species should be placed in *Gomphus* is pertinent but in that genus the species have solid stipes at first. Coker (1919) described this fungus under the name *C. sinuosus* Fries.

9. *Craterellus cornucopioides* Pers., Myc. Eur. 2: 5. 1825.

Pileus 2-7 cm broad at widest point, infundibuliform when expanded and in stature somewhat resembling *C. fallax,* with a perforated disc connecting to the hollow apex of the stipe, surface wrinkled to smooth but unbroken, dark

drab to blackish and fading to dark cinereous, margin slightly reddish brown when fading. Context thin, rather brittle; taste mild, odor sweetly fragrant; $FeSO_4$ no reaction; KOH no distinctive reaction.

Hymenium smooth but becoming veined near pileus margin (rarely with poorly formed gills), bluish drab developing vinaceous-buff tones and dingy ochraceous as dried, decurrent to near base of basidiocarp.

Stipe 2-3 cm long (the part without hymenium), 3-4 mm at base and evenly enlarged upward, hollow finally nearly to base, blackish, dark gray when dried, pallid at base when fresh but lacking any obvious mycelial coating.

Spore deposit "cartridge-buff" (darker ochraceous as air-dried); spores 8-11 x 5-6.5 μ, somewhat ovoid, smooth, thin-walled, hyaline in KOH and nearly so in Melzer's. Basidia 44-62 x 9-12 μ, 4-spored, content weakly brownish ochraceous in Melzer's. Pleurocystidia none. Hyphae of pileus cutis interwoven, 4-10 μ diam., frequently septate but not disarticulating, content in Melzer's showing small droplets not distinctively colored. Clamp connections absent.

Gregarious under conifers, Aug. 7, 1967, Montmorency County, Mich. Smith 74836.

Observations: The basidiocarps are not as thin as those of *C. fallax* but do resemble specimens of *C. cornucopioides* collected by R. Shaffer in France. The spores of Shaffer's material were not pinkish in deposit. Burt (1914) reports studying a specimen of *C. sinuosus* from Romell in which the hymenium dried somewhat chamois colored and has spores 10-12 x 6-7 μ, but *C. sinuosus* is not described as similar to *C. cornucopioides* in stature. It is very likely true that many of the septa in the cuticular hyphae of all these species are secondary, but the cells do not disarticulate (separate), and so it is not obvious: 1) which septa are secondary since clamps are absent, and 2) which septa differ chemically since none of the cells disarticulate. Hence my collection is not a *Pseudocraterellus.* Dr. Ronald Petersen is at present reviewing the status of the latter genus so it will not be discussed further here. *C. ochrosporus* Burt, because of its large spores, is close.

10. *Craterellus fallax* sp. nov.

Fig. 8.

Pileus 2-6 (8) cm latus, infundibuliformis, siccus, scabrosus, subatratus. Contextus fragilis; sapor mitis. Hymenium leve vel rugosum, cinereum vel fuscum. Stipes 4-10 cm longus, cavus, deorsum attenuatus, cinereus vel subatratus. Sporae 11-14 x 7-9 μ, leves. Fibulae desunt. Typus: Smith 64571 (MICH).

Basidiocarp 2-6 (8) cm broad across the top, 4-8 (10) cm high, trumpet-shaped, the flaring margin entire to wavy or lobed or frayed, often rather deeply incised when old and becoming quite ragged; upper surface and the interior of the trumpet dry and unpolished and scabrous to merely rough or varying to slightly squamulose, when wet fading as if hygrophanous, blackish when wet but fading to dingy grayish brown or wood-brown and drying dark wood-brown to cinnamon-drab. Context very thin, moderately brittle; odor and taste not distinctive or the odor faintly fragrant.

Hymenophore smooth to rugose-wrinkled, never with a pattern of well-formed forking veins near the pileus margin, fuscous-glaucous to dark cinereous

and with a buff to salmon-buff tinge as spores mature, dark cinereous to buffy cinereous as dried.

Stipe if distinct with only a short zone lacking hymenium and this area appearing unpolished rather than waxy, hollow, tapered down to the base.

Spore deposit salmon buff in a good deposit. Spores 11-14 x 7-9 μ, broadly elliptic in face view, in profile subelliptic (the ventral line in optical section nearly straight), smooth, nearly hyaline in KOH, pale yellowish in Melzer's, wall thin.

Basidia 60-80 x 7-9 μ, 2- and 4-spored, narrowly clavate to clavate, often only 3 μ thick at the basal cross wall, sections of hymenium bister in KOH (but single cells hyaline or nearly so), in Melzer's dark dingy yellow-brown in sections from amorphous debris adhering to the hyphal walls. Cystidia none.

Subhymenium basically of interwoven much-branched hyphae with cells 3-9 μ diam. and often of irregular shape, hyphae dingy yellow-brown in Melzer's. Basidia fasiculate. Hymenopodial zone scarcely distinct, intergrading with pileus context. Pileus context of interwoven hyphae mostly 6-9 μ diam. and with cells uninflated but also some hyphae present with inflated cells to 9-15 μ but narrow hyphae 3-5 μ diam. also present. Context hyphae dingy dark yellow-brown in Melzer's from amorphous debris but the cell walls themselves also dingy yellow-brown in Melzer's. Epicutis of closely appressed hyphae of the same type as those making up the context of the pigmentation more pronounced. Clamp connections none.

Habit, habitat, and distribution: Scattered, gregarious to cespitose on the ground in deciduous and mixed forests throughout the state, common in the summer and early fall especially during wet seasons.

Observations: This is the species that has long passed as *Craterellus cornucopoides* in this country. I have hesitated for years to describe it as a different taxon, but Corner in his recent monograph sets forth an extremely ambiguous concept in which the spores are described as white at first drying ochraceous, and includes many variants based on spore size. It seems that the species is so well known in Europe that critical studies correlating microscopic features with macroscopic characters are lacking. But one feature seems clear, Europeans do not regard *C. cornucopioides* as having a salmon-tinged spore deposit.

CANTHARELLUS Fries, Syst. Myc. 1: 316. 1821.

Chanterel Earle, Bull. N. Y. Bot. Gard. 9: 407. 1909.

Pileus funnel-shaped, in species with narrow stipes with the disc often perforated and the hollow continuous with that of the stipe. Lamellae absent (the hymenium smooth) to present as conspicuous folds or in age with lamellae having fairly acute edges, if the hymenium is smooth or nearly so the color is yellow or orange or pinkish; stipes solid or hollow and not typically merismoid in Michigan species. Spores smooth, non-amyloid, white to yellowish or pinkish in deposits. Clamp connections present.

Type species: *Cantharellus cibarius*

Key to Species

1. Stipe hollow or soon becoming so in the upper half 2
1. Stipe solid and not becoming hollow 8
2. Spore deposit white 3
2. Spore deposit yellowish to pinkish 5
3. Mycelium at base of stipe mustard yellow . . . . . 16. *C. subperforatus*
3. Stipe naked at base or with scant pallid mycelium 4
4. Lamellae more or less poroid by maturity; basidiocarp very fragile . . . . . 17. *C. convolvulatus*
4. Lamellae distant and never poroid; basidiocarp pliant . . . . . 18. *C. tubaeformis*
5. Spore 8-11 x 7-9 μ, subglobose . . . . . 11. *C. sphaerosporus*
5. Spores 9-13 x 6.5-8 μ, ovate to elliptic 6
6. Pileus blackish brown to date-color . . . . . 12. *C. infundibuliformis*
6. Pileus if yellow-brown at first soon yellow to orange and hymenium bright colored from the first 7
7. Lamellae poorly formed or hymenial surface smooth at first . . . . . 14. *C. lutescens*
7. Lamellae distinct at an early stage of development . . . . . 13. *C. minor*
8. Lamellae rudimentary . . . . . 15. *C. lateritius*
8. Lamellae distinct at an early stage 9
9. Basidiocarp cinnabar-red overall when young and fresh . . . . . 20. *C. cinnabarinus*
9. Not colored as in above choice 10
10. Watery lilac in stipe apex when fresh . . . . . 19. *C. septentrionalis*
10. Not as above 11
11. Gills pallid when young; spore deposit with a salmon-color tinge . . . . . 22a. *C. cibarius* var. *pallidifolius*
11. Lamellae yellow to orange when young and fresh 12
12. Pileus bright orange and spore deposit "orange-buff" . . . . . 21. *C. friesii*
12. Pileus egg-yellow to paler, and spore deposit weakly ochraceous . . . . . 22. *C. cibarius* var *cibarius*

11. *Cantharellus sphaerosporus* Peck, Bull. Torrey Bot. Club 25: 323. 1898.

Pileus 1.5-3 cm broad, plano-depressed with an incurved margin, becoming plano-depressed or finally somewhat funnel-shaped, margin thin and undulating to wavy or crenate in age, disc becoming perforated, glabrous, subhygrophanous, yellowish gray when moist, fading to grayish and in age or when dried pale drab, surface becoming lacerated at times in age. Context thin, yellowish to grayish; odor slightly fragrant, taste mild.

Lamellae decurrent, narrow, close to distant, edges obtuse, often forking near pileus margin, grayish ochraceous to avellaneous, when dried with a buff tone over the gray.

Stipe 3-6 cm long, 3-6 mm thick, equal or nearly so, hollow, pliant, glabrous, dull to bright ochraceous orange, when dry ochraceous tones still showing but clouded with gray Spore deposit pale yellow (near "warm buff"); spores subglobose, 8-11 x 7-9 μ, smooth, hyaline in KOH, yellowish in Melzer's, thin-walled.

Basidia 56-74 x 9-11 μ, 4- or 6-spored, nearly hyaline in KOH, yellowish in Melzer's (in groups dingy yellow-brown), walls flexuous, in KOH bister in sections but nearly hyaline individually. Pleurocystidia and cheilocystidia none.

Subhymenium of interwoven hyphae with cells enlarged up to 15 μ at times and much-branched; this layer merging into the context and central strand which are of similar hyphae only slightly more compactly interwoven, hyphae

5-9 μ diam., and with few inflated cells, content (in KOH) slightly brownish as seen under an oil immersion lens, bister in sections of the hymenium, dingy yellow-brown in Melzer's. Epicutis of hyphae similar to those of context. Clamp connections present.

Habit, habitat, and distribution: Gregarious to scattered in a cold *Thuja* bog, Burt Lake, Cheboygan County, Michigan, Oct. 14, 1960. Rare in the state.

Observations: The combination of subglobose spores, yellowish tones of the pileus, bright orange stipe, and pale yellow spores distinguishes this species in the stirps *Infundibuliformis.* We have no data on its edibility, but would rate it not recommended because of its close relationship to *C. infundibuliformis.*

12. *Cantharellus infundibuliformis* Fries, sensu Smith & Morse, Mycologia 39: 533. 1947.

Fig. 9.

Pileus 2-3.5 cm broad, convex, depressed or expanding to broadly infundibuliform with irregular wavy margin or margin sulcate at times, surface glabrous, moist and hygrophanous, color evenly blackish brown ("mummy-brown") to dark dingy yellowish brown ("bister") before fading to avellaneous or ochraceous-gray; disc often perforated in young specimens. Context watery and thin; odor faintly fragrant, taste mild.

Lamellae distant, narrow, decurrent, forked, edges obtuse and even, color "pale brownish-drab" (pale violaceous-brown) and glaucous (rather waxy in appearance).

Stipe 3-6 mm thick at apex, narrowed downward, glabrous, naked, lemon-yellow, with a whitish pith, sometimes tinged with umber in apical region, basal mycelium when visible pallid.

Spore deposit "pale pinkish-buff" (ochraceous); spores 9-12 x 6.5-8 μ, broadly ovate to broadly elliptic varying to subglobose, thin-walled, smooth, pale yellowish in Melzer's, sterigmal appendage distinct but small.

Basidia 50-65 x 8.5-11 μ, 2-, 4-, or rarely 6-spored, in sections of hymenium pale bister in KOH, single basidia nearly hyaline, sterigmata "Clavulina-like" (with prominent curved sterigmata); wall somewhat flexuous in lower two-thirds. Pleurocystidia and cheilocystidia none but some septate filaments found in the hymenium and some evidence indicating indeterminate growth of the hymenium present.

Subhymenium of frequently branched hyphae 5-8 μ in diam., arranged approximately parallel to the basidia and causing the base of the hymenial area to be rather dense and cellular; hymenopodial zone on the other hand of very loosely interwoven hyphae presenting an "open" appearance in sections. central strand of the trama of closely interwoven hyphae of about the same diameter and type as make up the pileus context. Content of pileus of thin-walled smooth hyphae brownish in mass but hyaline individually (in KOH), 6-15 μ broad and the cells either uninflated or only slightly inflated, compactly interwoven. Epicutis of pileus of hyphae like those of the context but more compactly

interwoven and the cells both slightly narrower and less inflated. Clamp connections regularly present at the septa of the hyphae in the pileus and lamellae.

Habit, habitat, and distribution: Gregarious on *Sphagnum,* Tahquamenon Falls State Park, Luce County, Michigan, August 22, 1955, Smith 50289. This species is almost as common as *C. tubaeformis* in Michigan and is often confused with it.

Observations: The collection cited above, as close as I could discern, is identical with material I collected in England. Hence Corner's statement (with a question mark) that the spores of this species are white indicates to me that both *C. tubaeformis* and *C. infundibuliformis* may occur there. This species is not recommended for the table.

13. *Cantharellus minor* Peck, Rep. N. Y. St. Mus. 23: 122. 1872.

Figs. 12, 14.

Pileus (1) 2-4 (8) cm broad, broadly convex to nearly plane at first, margin incurved, at times the disc sharply depressed from the beginning, expanding to shallowly infundibuliform and with a wavy and irregular margin, disc often perforated (especially in age) and in large pilei the perforation broad and merely an extension of the follow of the stipe, in young pilei the surface minutely squamulose to fibrillose scurfy or practically glabrous, in age more often uneven than scaly, moist and hygrophanous, bright orange-yellow ("capucine-yellow"), duller when faded ("pale yellow-orange" or more dingy), grayish when dried. Context soft and fragile, concolorous with pileus; odor slight but fragrant, taste somewhat unpleasant.

Lamellae distinct and well formed, decurrent, narrow, subdistant, mostly forked once near pileus margin, becoming conspicuously intervenose "ochraceous salmon" varying to "vinaceous-cinnamon" (salmon-yellow becoming dingy yellowish vinaceous), edges obtuse.

Stipe 3-6 cm long, 4-10 thick, central or eccentric, hollow, glabrous, "capucine-yellow" or darker orange moist, gradually fading to dingy yellowish, not discoloring when handled.

Spore deposit "ochraceous-salmon" (pinkish); spores 9-13 x 6-8 μ, broadly ellipsoid, smooth, thin-walled, hyaline in KOH and yellowish in Melzer's. Basidia 4- and 6-spored, 70-90 x 8-11 μ. Pleurocystidia and cheilocystidia none.

Subhymenium of much branched hyphae 5-9 μ diam., oriented approximately parallel to the basidia; hymenopodium not separated from the central strand (both of interwoven hyphae). Epicutis of pileus hardly distinguishable from the context, both of interwoven hyphae 5-9 μ diam. with thin smooth walls and practically hyaline in KOH, merely yellowish in Melzer's. Clamp connections present.

Habit, habitat, and distribution: Gregarious to cespitose or scattered on humus in the oak-aspen association of central Michigan, common and abundant during wet seasons in July and August. It is often found along old logs almost reduced to humus.

Observations: This is the species I (1953) previously tried to identify as *Cantharellus lutescens.* On the basis of Corner's work I am convinced this was an

error. Peck described *C. minor* with a stipe that was hollow, a pileus egg yellow and gills yellowish. The Michigan material fits this description well except that the spores are larger and the pileus apparently more squamulose though the latter character is quite variable in the material I have seen. Because of the discrepancy in spore size, Peck's name is used here provisionally. It should be remembered, however, that most *Cantharellus* species with hollow stipes have large spores.

14. *Cantharellus lutescens* Fries, Syst. Myc. 1: 320. 1821.

Fig. 10.

Pileus 2.5-6 cm broad, at first with the disc depressed and the margin sharply decurved (but not incurved) and frayed to serrate (under a hand lens at first), in age variously lobed and undulating or crenate and extreme edge serrate to ragged; plano-depressed to infundibuliform in age and disc often becoming perforated; color when young dingy yellow-brown ("Saccardo's umber"), gradually becoming a brighter yellow ("ochraceous-buff" to "ochraceous-salmon"), at times the margin slightly virgate with dark lines ending in point-like dark squamules, not hygrophanous. Context thin and pliant; odor (of large numbers of basidiocarps) somewhat fragrant, taste not distinctive.

Hymenophore smooth to shallowly wrinkled or in age more like folds but not gill-like, decurrent down the stipe in age, with a waxy sheen, "ochraceous-orange" becoming "ochraceous-salmon" as spores mature.

Stipe 5-8 cm long, 4-6 mm thick at apex, 3-4 mm at the base, hollow, uneven, glabrous, more or less ochraceous-orange, base with thin whitish mycelium.

Spore deposit "ochraceous-salmon" or slightly paler (pinkish); spores 9-12 x 6.5-8 μ, ovate to elliptic in face view, in profile subovate to obscurely inequilateral, dingy yellowish in Melzer's, yellowish hyaline in KOH, smooth, thin-walled, sterigmal appendage minute and oblique.

Basidia 4- to 6-spored, 48-70 x 9-12 μ, hyaline in KOH, dingy yellowish in Melzer's, flexuous, narrowly clavate. Cystidia none.

Subhymenium of interwoven hyphae 5-10 μ in diam., and intergrading with hyphae of context; context hyphae interwoven, 6-12 μ diam., branching sparse to moderate and septa not numerous, walls slightly thickened (0.5-0.7 μ), dingy yellowish in Melzer's. Epicutis of pileus of radial hyphae more frequently branched but otherwise similar to those of the context, appressed. Clamp connections present; rarely 2 occur at a single septum.

Habit, habitat, and distribution: Gregarious to scattered on wet moss in bogs and cold springy habitats, common in late summer and early fall in northern Michigan. The description is of Smith 22149, from near Burt Lake, Aug. 20, 1964.

Observations: The spores are broad, as in the *C. infundibuliformis* stirps, and the aspect of the basidiocarp is also similar, but the hymenophore is basically nearly emooth to undulating or finally radiately wrinkled. The configuration of the hymenophore is actually a very constant feature. I have observed the species in marked localities over a 20-year period and the range of variation is

clearly limited as specified above. The pink in the spore deposit may not show in thin deposits.

15. *Cantharellus lateritius* (Berk.) comb. nov.

Craterellus lateritius Berkeley, Grevillea 1: 147. 1873.

Fig. 11.

Pileus 2.5-5.5 cm broad, plane to slightly depressed or finally broadly infundibuliform, marginal portion typically undulating and arched, more or less glabrous but appearing minutely squamulose in the disc on drying, surface actually uneven, "zinc-orange" to "capucine-yellow" (bright orange-yellow), hygrophanous and fading to pale buff ("light ochraceous-buff" or "capucine-buff") when dried uniformly pale buff. Context moderately thick, 4-7 mm in disc and tapered to the margin, soft and moderately brittle, white to pale buff, near the margin concolorous with the surface; odor mild when fresh, after drying resembling that of *Cantharellus cibarius,* taste slightly bitter but soon fading.

Lamellae crowded, narrow, irregularly forking, no more than 0.5 mm broad and up to 0.7 mm high, decurrent, edges obtuse and entire, "capucine-buff" to "ochraceous buff" (orange-yellow to pale ocher-yellow), at times "pale ochraceous-salmon," in young specimens the hymenial surface may be nearly smooth.

Stipe 1.7-4.5 cm long, 10-16 mm thick at apex, 5-8 mm thick near base, straight or curved, terete or compressed, solid, in age often channeled by larvae, fleshy-fibrous, concolorous with lamellae or slightly darker.

Spore deposit pinkish-ochraceous; spores 7-9 x 4.5-5.5 μ, ovoid to ellipsoid, hyaline in KOH, yellowish in Melzer's, thin-walled, smooth.

Basidia 4- and 6-spored, 36-52 x 7-9 μ, narrowly clavate, flexuous, yellowish in Melzer's, in KOH hyaline but with highly refractive banded content (resembling a strand of coagulated protoplasm). Cystidia 50-60 x 3.5-5 μ, flexuous-cylindric with apex tapered to a subacute point, numerous (the young basidia were clavate at apex). Content similar to that of basidia and basidioles.

Subhymenium showing the candelabrum-type branching and hymenopodial zone of loosely interwoven hyphae, the central strand if one is present a slight projection downward of the context of the pileus. Context of pileus of interwoven hyaline thin-walled hyphae not greatly inflated and vary compactly arranged, yellow in KOH and slightly more so in Melzer's. Epicutis of pileus a loosely interwoven layer of hyphae having slightly thickened walls and the cells readily disjointing and littering the mount with fragments 1-3 cells long and the cells of various degrees and patterns of inflation but always 2 times or more longer than broad and 3-8 μ in diam. Clamp connections present.

Habit, habitat, and distribution: Gregarious on soil in deciduous woods, Warren Woods, Berrien County, Aug. 16, 1958. R. B. Howard and R. L. Shaffer 2064.

Observations: This is the only record from Michigan which we have of this species. Because of the pinkish tint of the hymenophore in older specimens we assume the spore-print would have had a tint of salmon in it but this was not verified on the collection cited. The statement on spore color is the only

character in the above description taken from the literature. The diagnostic characters are the disarticulating cuticular hyphae and their slightly thickened walls, the reduced type of hymenophore as compared with *C. cibarius,* and the generally southern distribution. The presence of cystidia may be a very important character as such structures are not typical of the genus but I should like to verify it from additional collections. The absence of a fragment odor when fresh may also be significant. *"Craterellus cantharellus"* is the same but since the epithet *cantharellus* cannot be transferred, it becomes necessary to use Berkeley's epithet. Burt (1914) studied Berkeley's type. Since *C. odoratus* is described as having a hollow stipe, Shaffer's collection can hardly be placed there.

16. *Cantharellus subperforatus* sp. nov.

Pileus 2.5-6 cm latus, plano-depressus, ad marginem recurvatus, demum infundibuliformis, atrospadiceus demum sordide luteobrunneus, glaber, rugulosus. Contextus tenuis. Odor fragrans. Sapor mitis. Lamellae angustae, decurrentes, distantes, caeruleofuscae demum ochraceotinctae. Stipes 4-6 cm longus, 4-8 mm crassus, cavus, sursum subfuscus, deorsum sordide aurantio-ochraceus. Mycelium laete olivaceoluteum. Sporae 8-11 x 7-9 μ. Typus: Smith 62936 (MICH).

Pileus 2.5-6 cm broad, plano-depressed at first, the margin somewhat incurved, finally recurved, expanding to broadly infundibuliform and the margin becoming sulcate to wavy or even or lobed, sometimes becoming perforated in the center in a rather inconspicuous manner, blackish brown ("mummy-brown") when young and fresh, slowly becoming "snuff-brown" (dingy yellow-brown) before fading to ochraceous gray, surface glabrous, smooth or becoming wrinkled in age. Context thin and pliant; odor faintly fragrant, taste mild; no reaction to KOH.

Lamellae narrow, decurrent, distant, edges obtuse, many formed near pileus margin, bluish drab toned ochraceous finally from spores but drab to hair-brown when dried.

Stipe 4-6 cm long, 4-8 (10) mm thick at apex, equal or variously enlarged at apex and/or base, hollow, often compressed in age, naked, dull ochraceous-orange below, clouded with the gill color toward the apex; mycelium mustard yellow.

Spore deposit white; spores 8-11 x 7-9 μ, broadly ovate to elliptic or subglobose, smooth, thin-walled, yellowish in Melzer's, sterigmal appendage distinct.

Basidia 6- and 8-spored, 60-90 x 9-12 μ, with long flexuous pedicels, yellowish in Melzer's, lacking granules in the interior, sections bister in KOH but single basidia nearly hyaline. Pleurocystidia and cheilocystidia absent.

Subhymenium compact, the hyphae frequently septate, the elements mostly about parallel with the basidia but toward hymenopodium more interwoven; hymenopodial area of loosely interwoven hyphae (the area as seen in revived sections appearing nearly empty), the central strand of compactly interwoven hyphae similar to those of the context; hyphae of pileus context interwoven, mostly of uninflated cells 6-11 μ diam., the walls thin and smooth, hyaline, or faintly colored when compactly arranged. Epicutis of pileus of hyphae like those of the context, appressed-interwoven. Clamp connections present.

Habit, habitat, and distribution: Gregarious on moss and duff in a cold *Abies-Thuja* bog, Burt Lake, Cheboygan County, Aug. 18, 1960. Smith 62936.

Observations: The distinguishing features of this species are the mustard yellow mycelium, white spore deposit, presence of clamp connections, and the fact that the gills dry without any yellowish tones. It is most closely allied to *C. tubaeformis* Fr. sensu Smith. Nothing is known of its edibility but I would not recommend it.

17. *Cantharellus convolvulatus* sp. nov.

Fig. 13.

Pileus 3-7 cm latus, irregulariter infundibuliformis, ad marginem lobatus et convolvulatus, perforatus, glaber, hygrophanus, luteo-brunneus demum ochraceus, deinde ochraceo-griseus. Contextus fragilis, sapor mitis; odor nullus. Lamellae decurrentes angustae (venosae), vinaceo-griseae. Stipes 2-5 cm longus, 6-12 mm crassus, fragilis, cavus, glaber, sordide aurantiacus. Sporae in cumulo albidae, 9-13 x 6.5-8.5 μ, late ellipsoideae. Typus: Shaffer 2518 (MICH).

Pileus 3-7 cm broad, irregularly funnel-shaped with a crinkled to irregular lobed and wavy margin, perforate at disc in age, surface glabrous, moist, hygrophanous, the margin translucent striate at times or remaining opaque, color "buckthorn-brown" (a dingy yellow-brown) to dingy ochraceous when moist, fading to dingy grayish ochraceous and drying avellaneous, to wood-brown. Context very fragile, concolorous with surface; taste mild, odor none; KOH and $FeSO_4$ both entirely negative.

Lamellae decurrent, foldlike, intervenose to irregularly poroid or compound poroid (with small pores grouped within larger ones—the hymenium very irregular in appearance, "vinaceous-fawn" to "wood-brown" in color but near avellaneous when dried, remaining readily visible on the dried specimens.

Stipe 2-5 cm long, 6-12 mm thick at apex, very brittle, equal or either slightly narrowed or slightly enlarged downward, soon hollow, surface glabrous and dull orange, cortex orange.

Spore deposit white; spores 9-12 x 6.5-8 μ, thin-walled, smooth, oval to broadly ellipsoid, greenish hyaline and granular in KOH, merely pale yellowish to hyaline in Melzer's.

Basidia 2- and 4-spored, 50-65 x 9-12 μ, narrowly clavate with somewhat flexuous walls, frequently becoming secondarily septate. Pleurocystidia and cheilocystidia none but some filaments present which become 2-5 septate and with the cells sometimes inflated to 10-15 μ, walls of hymenial elements smooth and pale brownish in KOH (nearly hyaline individually).

Subhymenium of subparallel to interwoven hyphae 7-9 μ diam. terminating in a basidium, often 2-5 septate below the terminal cell, some inflated hyphal cells present near the central tramal strand and these 9-15 μ diam. and often irregular in shape, the walls of subhymenial elements pallid brownish as seen in sections. Central area of gill trama of interwoven thin-walled hyphae with practically hyaline walls, some hyphae uninflated and others with cells inflated 12-20 μ, mostly 8-13 μ in diam., branching rather frequent. Epicutis of pileus of appressed-interwoven hyphae only slightly more compactly arranged than those of the context but all the hyphae 6-11 μ diam., smooth and lacking appreciable

pigmentation (though sections in KOH are brownish), merely yellowish in Melzer's. Clamp connections present regularly on hyphae of context and gill trama; also at base of basidium.

Habit, habitat, and distribution: Gregarious at edge of a bog in an oak-hickory woods, Pinckney Recreation Area, Washtenaw County, Aug. 5, 1960. R. L. Shaffer 2518 (type).

Observations: This *Cantharellus* is characterized by being very fragile, yet the hyphae do not disarticulate; the hymenium becomes shallowly poroid by maturity and is more or less avellaneous in color. The white spore deposit distinguishes it from *C. friesii* in the sense of the latter in this work.

18. *Cantharellus tubaeformis* Fries, Syst. Myc. 1: 319. 1821.

Fig. 15.

Pileus 1-3 (5) cm broad, convex to plane or broadly depressed and with an arched incurved margin when young, margin finally spreading or uplifted and becoming crenate to variously lobed, occasionally somewhat funnel-shaped in age, surface moist and more or less uneven, at times with radial ridges terminating in scabrous points, sometimes quite rough, sometimes practically glabrous, usually not perforated in the disc at first but frequently becoming so in age, moist, color "Saccardo's-umber" to "sepia" (dark sordid yellowish brown), at times more or less sordid ochraceous. Context thin and membranous, fragile, yellowish to avellaneous; odor and taste not distinctive.

Lamellae decurrent, narrow and with obtuse edges, subdistant to distant, forked near pileus margin and variously veined, yellowish gray to "avellaneous" often pale drab in age, creamy ochraceous-buff when dried.

Stipe 3-6 cm long, 3-7 mm thick, stuffed but becoming hollow and flabby, subequal, terete or compressed, smooth or furrowed, glabrous, dark to pale ochraceous above, usually whitish at the base.

Spore deposit white to creamy white; spores (8) 9-11 x 6-8 μ, ellipsoid to ovoid, smooth, thin-walled, hyaline in KOH, yellowish in Melzer's (rarely pale tawny).

Basidia 4-, 6-, or 8-spored, clavate, 3.5-5 μ at base, 9-12 μ at apex, hyaline individually in KOH, yellowish in Melzer's. Pleurocystidia and cheilocystidia absent.

Subhymenium of the candelabrum-type, the "pedicels" making up the hymenopodial zone, central strand of interwoven thin-walled smooth hyphae 5-11 μ diam. and cells uninflated; hyphae of pileus context similar. Epicutis of pileus of appressed hyphae like those of the context. Clamp connections present.

Habit, habitat, and distribution: Gregarious to scattered on *Sphagnum* in bogs or on other mosses in cold springy areas, late summer to late fall; common through the state wherever the right habitat exists.

Observations: This is the concept proposed in Smith and Morse (1947) and the one I shall continue to use until it is clearly shown that such a white-spored *Cantharellus* does not exist in Europe. For further comment see *C. infundibuliformis*. This species is not recommended for the table. Some in this group cause mild cases of poisoning and the taxomony of the group is in such a state that it is hard to be sure which variants are causing the trouble.

19. *Cantharellus septentrionalis* sp. nov.

Pileus 2-3 cm latus, convexus, siccus, laete luteus, demum ad centrum pallidus et subsquamulosus. Contextus luteus, tactu subfulvus. Odor fragrans. Sapor subacris. Lamellae angustae, bifurcatae, subdistantes, luteae. Stipes 2-3 cm longus, 6-10 mm crassus, sursum intus aquose-lilaceus, deorsum pallidus, extus sordide luteus. Sporae in cumulo citrinae, 8-10 x 6-6.5 μ. Typus: Smith 67052 (MICH).

Pileus 2-3 cm broad, convex with an incurved margin, surface dry and matted-fibrillose, "antimony-yellow" when fresh, soon pallid-canescent over the disc, when mature diffracted scaly over all but disc, the squamules very minute but giving pileus a rough appearance (not scaly as in *G. floccosus*). Context yellow under the cuticle, paler in central area, staining orange-tawny when bruised; odor fragrant, taste slightly peppery; with $FeSO_4$ watery grayish in stipe apex, KOH no reaction.

Lamellae narrow, folklike, forked, decurrent, "buff-yellow" or paler and brighter, edges obtuse and even.

Stipe 2-3 cm long, 6-10 mm at apex, solid, watery-lilac in apex when cut, pallid below, solid, surface dry and unpolished, a duller paler yellow than the gills and staining orange-tan where bruised.

Spore deposit lemon-yellow; spores 8-10 x 6-6.5 μ, smooth, inamyloid, in face view elliptic, in profile slightly allantoid, hyaline in KOH. Basidia 10-12 μ broad at apex, 4-spored, hyaline in KOH, yellowish in Melzer's. Pleurocystidia and cheilocystidia none. Subhymenium of more or less interwoven hyphae connecting to a poorly defined central strand. Pileus cutis of appressed hyphae 5-8 μ diam. hyaline in KOH and Melzer's, walls smooth and thin, content not distinctive in Melzer's. Clamp connections present.

Habit, habitat, and distribution: Gregarious to cespitose, Tahquamenon Falls State Park, Luce County, Aug. 7, 1963. Smith 67052.

Observations: This species is close to *C. cibarius* but has narrow fold-like ridges for gills, the context at the apex of the stipe is lilaceous, and the spore deposit when fresh is lemon-yellow. Its edibility has not been tested, but it would be surprising if it were poisonous.

20. *Cantharellus cinnabarinus* Schweinitz, Trans. Am. Philos. Soc. 2: 4. 1832.

Fig. 16.

Pileus 1-5 (7) cm broad, plano-convex, expanding to shallowly infundibuliform, margin incurved at first, in age spreading to uplifted and variously crenate, lobed or wavy, at times in age the margin very irregular, often unpolished when young, soon naked, glabrous, color evenly cinnabar-red to reddish orange, fading rapidly in sunlight and finally often nearly pallid, dried specimens pale buff. Context thin toward the pileus margin, flushed pinkish at first but soon pallid; taste slowly burning acrid, odor not distinctive when fresh but dried specimens for a time at least faintly fragrant as in *C. cibarius*; inky green with Melzer's on pileus, $FeSO_4$ no reaction or finally watery vinaceous, KOH no change.

Lamellae close to subdistant, varying to distant, long-decurrent, narrow, edges obtuse, conspicuously intervenose or at times shallowly poroid, concolorous with pileus when fresh but soon paler, when dried more ochraceous than the pileus, not staining when injured.

Spore deposit delicately pinkish (in a thick deposit); spores 7-9 x 4.5-5.5 μ, elliptic in face view, in profile subelliptic or ventral line straight to slightly concave, thin-walled, smooth, hyaline in KOH and merely yellowish hyaline in Melzer's.

Basidia 4- or 6-spored, 38-56 x 8-10 μ, narrowly clavate, hyaline in KOH or with yellowish content, yellowish in Melzer's. Pleurocystidia and cheilocystidia none.

Subhymenium and hymenopodial areas of equally densely interwoven hyphae, merging gradually into the central tramal strand, pale dingy yellowish brown in sections in KOH but individual hyphae hyaline, thin-walled, smooth, cells not appreciably inflated; hyphae of the pileus context compactly interwoven, yellowish in sections (in KOH), hyaline individually, walls thin and smooth, the cells equal to slightly enlarged either in the midportion or at the septa; epicutis of pileus of appressed hyphae like those of context, local areas of pileobasidia developing on raised areas. Clamp connections present.

Habit, habitat, and distribution: Solitary to gregarious in dry woods of oak and hickory or beech-maple, especially along woodland roads, summer, common during wet seasons.

Observations: The pilei show a marked tendency to develop patches of hymenium on the surface or even aborted secondary pilei and as a result may present a rather irregular appearance. The pinkish spore deposit, acrid taste, and cinnabar color are distinctive. From *C. friesii* it differs particularly in color and in the much more irregular pileus. It is edible but not usually found in sufficient quantity for a meal.

21. *Cantharellus friesii* Quélet, Champ. Jura et Vosges 1: 191. 1874.

Pileus 8-30 mm broad, broadly convex with an inrolled margin, becoming infundibuliform with a wavy-crenate margin, surface unpolished, opaque, when moist "capucine-orange" (bright orange), fading to egg-yellow (never as red as in *C. cinnabarinus*). Context thin, more or less concolorous with surface; taste slowly acrid, odor fragrant (as in *C. cibarius*); $FeSO_4$ dull vinaceous; KOH no reaction.

Lamellae narrow, close, forking, decurrent, edges obtuse, egg-yellow becoming paler, strongly intervenose.

Stipe 1.5-3 cm long, 5-7 mm thick, solid, equal, pallid within, surface unpolished and approximately concolorous with the pileus except for the whitish base.

Spore deposit "orange-buff"; spores 9-11 x 4.5-5.5 μ, smooth, nearly hyaline in Melzer's thin-walled, elliptic to ovate in face view, in profile oblong to slightly concave on the ventral line, nearly hyaline in KOH.

Basidia 40-60 x 9-12 μ, 4- to 6-spored, and the extra sterigmata at times lateral near the apex, narrowly clavate, the walls more or less flexuous, hyaline to yellowish in KOH, yellowish in Melzer's, secondary septa rare. Pleurocystidia and cheilocystidia none.

Subhymenium of interwoven hyphae 6-9 μ in diam., hymenopodium loosely interwoven and hyphae generally extending laterally toward the hymeni-

um, yellowish in Melzer's, thin-walled, hyphal cells mostly uninflated but up to 12 μ or more in diam.; central strand of more compactly interwoven hyphae but of the same type. Epicutis of pileus of appressed interwoven hyphae 6-12 μ broad and with free hyphal ends projecting singly or in groups but end cells not especially differentiated. Context of interwoven thin-walled, smooth more or less hyaline hyphae. Clamp connections present on context tramal hyphae and at base of basidium.

Habit, habitat, and distribution: Gregarious under hardwoods on moss and litter, Sharon Hollow, Washtenaw Co., August 4, 1960. Smith 62787.

Observations: This species truly is closely related to *C. cibarius* but is smaller, brighter orange over the pileus, has a dull vinaceous color change with $FeSO_4$ and the spores are "orange-buff" in a good deposit. It differs from *C. minor* in having a solid stipe.

22. *Cantharellus cibarius* Fries, Syst. Myc. 1: 318. 1821. var *cibarius*

Fig. 18.

Pileus (2) 3-8 (10) cm broad, broadly obtuse to plano-convex when young, the margin incurved and irregular, expanding to plane with a wavy margin, shallowly depressed or finally broadly infundibuliform, margin crenate to wavy or variously irregular and often lobed, at times deeply sinuate on one side, surface unpolished at first from a hoary coating, soon naked, not hygrophanous, pale to rich egg-yellow at maturity, slowly paler in age on exposure to light, staining greenish fuscous where touched with Melzer's reagent. Context thick, firm, yellowish to pallid; odor faintly fragrant, when dried odor decidedly fragrant, taste slightly peppery.

Lamellae decurrent, close to subdistant, at times distant in age, narrow, edges obtuse and even when young, subacute in age, egg-yellow or paler finally when dried typically orange-buff, very slowly staining more ochraceous when injured or the stains becoming visible only on the dried specimens.

Stipe 3-8 cm long, 5-15 mm thick at apex, equal or narrowed toward the base, solid, center pallid, cortex yellowish, glabrous, concolorous with pileus or paler at base, slowly bleaching on standing, slowly staining ochraceous when injured, or stains showing only on dried specimens.

Spore deposit pale ochraceous; spores 8-10 x 4.5-5.5 μ, in face view elliptic, in profile view slightly to obscurely allantoid or subelliptic, hyaline in KOH, yellowish in Melzer's smooth, thin-walled.

Basidia 4- to 6-spored, 48-67 x 8-10 μ, narrowly clavate, pedicel flexuous, hyaline in KOH, yellowish in Melzer's. Pleurocystidia and cheilocystidia none except for filaments 50-60 μ long and 3.5-5 μ wide scattered in the humenium (immature basidia?).

Subhymenium of hyphal cells oriented about parallel with the basidia and 3-5 μ diam.; hymenopodial zone not sharply distinct from the interwoven central strand, the hyphae of the latter hyaline individually, intricately interwoven, walls thin and smooth; hyphae of pileus context similar, hyphal cells not greatly inflated (5-12-15 μ wide). cuticle of pileus merely of more compactly arranged hyphae, above this a loose poorly formed epicutis of narrow (4-6 μ) thin-walled

non-gelatinous hyphae with the end-cells slightly clavate, hyaline in KOH. Clamp connections present.

Habit, habitat, and distribution: Cespitose to gregarious in deciduous woods, especially along old roads in the woods; from the fourth of July on into early autumn in Michigan. Common.

Observations: On the basis of specimens collected and studied in England I regard this as the type variety. Its diagnostic features are the slightly peppery taste developing slowly, the delayed staining to ochraceous when injured, fragrant odor especially when dried, buff colored spore deposit and the overall egg-eyllow coloration.

Edibility: This is one of the world's highly prized edible species. In our region, however, it is often difficult to find it free from insect larvae.

22a. *Cantharellus cibarius* var. *pallidifolius* var. nov.

Fig. 17.

Pileus 6-12 (15) cm latus, lateus; lamellae pallidae; sporae in cumulo salmonae. Typus: Smith 62993 (MICH).

Pileus 6-12 (15) cm broad, broadly convex with an incurved margin, rather irregular in outline, expanding to broadly convex, or shallowly depressed with a spreading to uplifted margin, margin lobed, wavy and crenate in age and presenting a very irregular appearance; surface dry and unpolished from a thin coating fibrils, glabrescent in age and not hygrophanous, pileus essentially buff-yellow to egg-yellow, about pinkish-buff when dried, staining ochraceous brown readily when bruised. Context thick, white, firm; odor fragrant, taste mild but slowly becoming peppery; $FeSO_4$ vinaceous brown; KOH intensifying the yellow of the pileus.

Lamellae close to subdistant, narrow, decurrent, edges obtuse, many forking or anastomosing and at times hymenophore practically poroid, color pallid when young but gradually becoming egg-yellow at least along margin and rather rusty ochraceous when dried.

Stipe 4-8 cm long, 1-3 cm thick, equal or narrowed downward, solid, white within, soon staining rusty ochraceous when injured, surface whitish and unpolished, gradually becoming yellow in aging and staining rusty ochraceous where injured.

Spore deposit ochraceous-salmon (flushed pink); spores 7-10 x 4.5-6 μ, oblong to elliptic in face view, slightly allantoid in profile, smooth, thin-walled, hyaline in KOH, yellowish in Melzer's.

Basidia (40) 60-90 x 7-9 μ, narrowly clavate, mostly 4-spored, hyaline in KOH, yellowish in Melzer's. Pleurocystidia and cheilocystidia none.

Subhymenium and hymenopodium one unit—with candelabrum-like branching of the hyphae; central strand of gill trama of compactly interwoven hyphae merging with the hyphae of the pileus context; pileus context of interwoven hyphae with thin smooth walls, the cells 5-9 (12) μ broad and mostly uninflated; pileus cutis of compactly appressed and interwoven hyphae like those of the context; epicutis a loose wheft of hyaline thin-walled hyphae 4-7 μ diam., the end-cells merely obtuse. Clamp connections present.

Habit, habitat, and distribution: Gregarious to scattered under young beech-maple second-growth, Pellston, Aug. 23, 1960. Smith 62993. Common in the state, from midsummer to late fall.

Observations: This is a variant with a large heavy basidiocarp which stains readily, has pallid gills in fresh young rapidly developing pilei, and has a pink tint to the spore deposit.

Edibility: This is the best of the variants of this species found in the state. It is also more frequently found free of insect larvae.

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Fig. 1. *Gomphus clavatus* ×1 Smith 54454

Fig. 2. *Gomphus clavatus* ×1 Smith 72549

Fig. 3. *Gomphus clavatus* ×1 Smith 62896

Fig. 4. *Gomphus floccosus* ×1 Smith 70616

Fig. 5. *Craterellus caeruleofuscus* ×1 Smith 42572

Fig. 6. *Craterellus cinereus* var. *multiplex* x1 Smith 37531

Fig. 7. *Craterellus foetidus* ×1 Smith 62498 (type)

Fig. 8. *Craterellus fallax* ×1 Smith 64571 (type)

Fig. 9. *Cantharellus infundibuliformis* ×1 Smith 17626

Fig. 10. *Cantharellus lutescens* ×1 Smith 75250

Fig. 11. *Cantharellus lateritius* x1 Smith 9966

Fig. 12. *Cantharellus minor* x1 Smith 74950

Fig. 13. *Cantharellus convolvulatus* x1 Shaffer 2518 (type)

Fig. 14. *Cantharellus minor* ×1 Smith 36985

Fig. 15. *Cantharellus tubaeformis* ×1 Smith 67743

Fig. 16. *Cantharellus cinnabarinus* x1 Smith 32847

Fig. 17. *Cantharellus cibarius* var. *pallidifolius* x1 Smith 62993 (type)

Fig. 18. *Cantharellus cibarius* var. *cibarius* ×1 Smith 28098

Nature education feature --

MAKING RUBBER DUPLICATES OF MUSHROOMS

Richard A. Mortemore
Kensington Metropolitan Park,
Milford, Michigan

The preparation of latex mushroom models can be a rewarding experience for the avid as well as for the casual mycologist. All too soon after being collected, most mushrooms begin to deteriorate. Unless the collector is also a photographer, the rich colors and symmetrical shapes become only a memory until the next season. With a little practice and artistic ability, a mushroom can be duplicated in latex within a matter of hours.

The materials required in this process are rather inexpensive. A good grade of plaster of paris, liquid latex, liquid green soap (available at pharmacies), cardboard, and oil paints or water colors are needed.

Select the mushroom to be duplicated with care. Make sure that it is not too soft and not perforated with too many worm holes. Carefully remove all foreign material such as dirt, grass, and leaves. This may be done with the use of forceps, water, or a stream of air. If the cap of the mushroom is sticky, such as that of *Boletus luteus,* thoroughly wash and dry it or the detail in the plaster will be poor.

Using a sharp knife, separate the cap from the stem. This step is not necessary for all species. A few, such as stinkhorns and morels, may be cast in one piece. (Fig. 1)

After separation of the mushroom cap, form two small cardboard boxes: one to contain the cap and the other to hold the stem horizontally. Do not form these containers excessively large or you will waste a great deal of plaster.

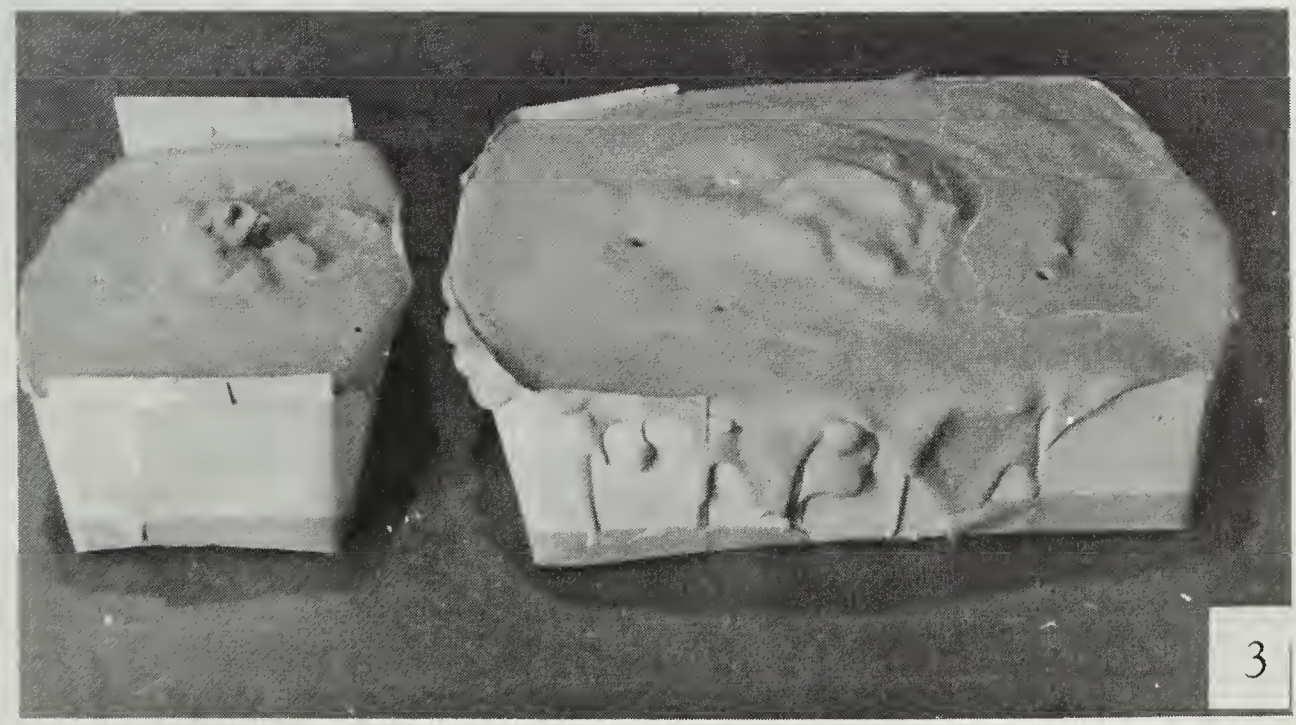
Mix your plaster to a creamy consistency and pour a small amount into your container for the cap. Place the cap, *gill* (or pore) side up, into the plaster. Make sure that a layer of plaster is between it and the bottom of the container. Add plaster until it reaches just to the *edge* of the gills. Pour plaster into the other container and immerse the stem halfway. Allow both to dry thoroughly. (Fig. 2) If the container in which the plaster was mixed is thoroughly washed before the plaster has a chance to harden, you will eliminate the problems of removing the accumulation of caked plaster.

After the plaster is dry, brush a small amount of green soap on the exposed plaster surface surrounding the mushroom. This allows the plaster halves to separate easily. Next, mix a new batch of plaster and pour it in the containers to completely cover the cap and the stem. Allow this to dry thoroughly. (Fig. 3)

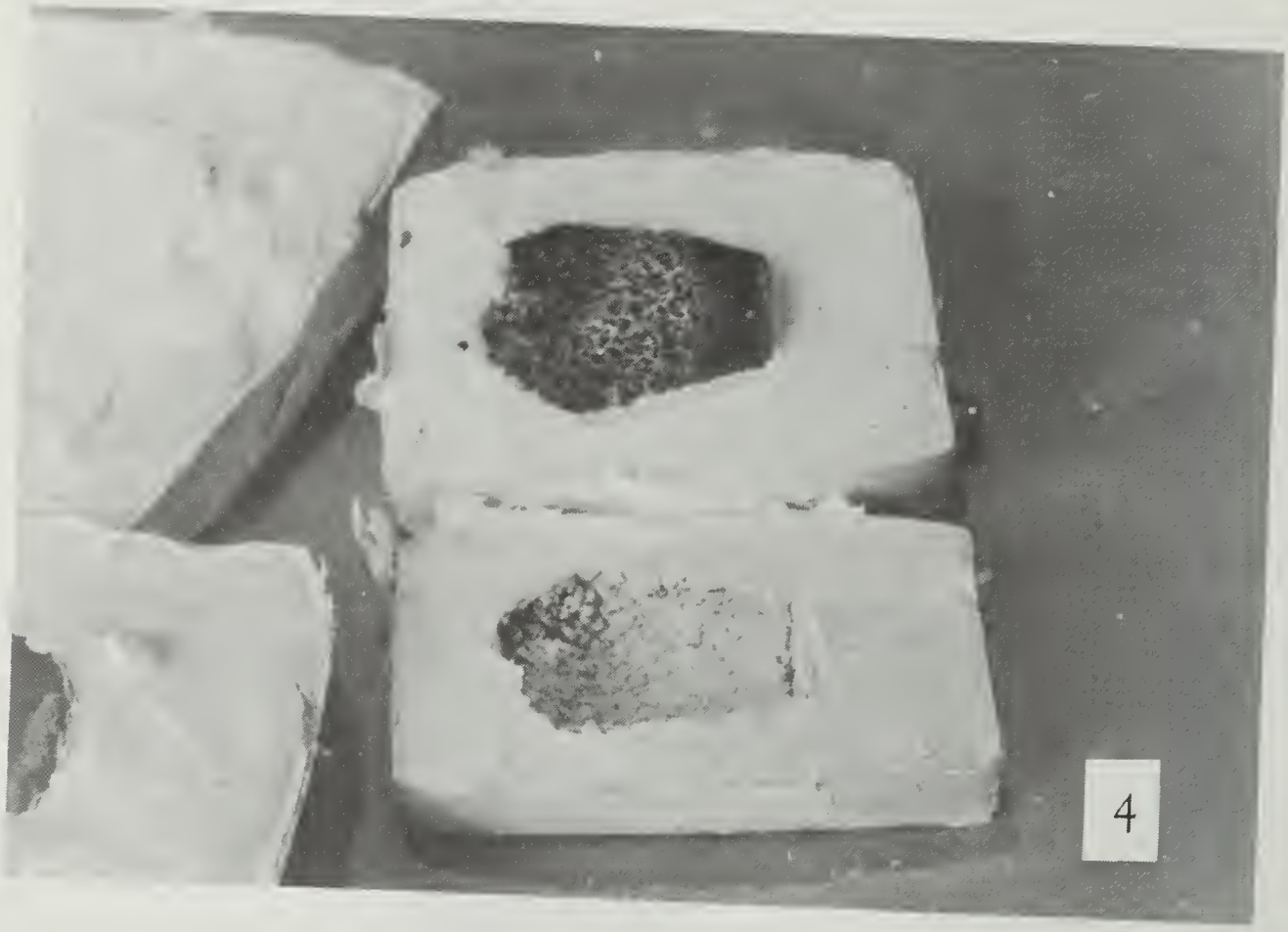
Using a knife, remove the cardboard container and carefully pry apart the plaster halves. Allow the exposed plaster surfaces to dry for at least thirty minutes, then remove the mushroom from the plaster. (Fig. 4) You may find that in certain species, especially boletes, part of the cap will stick to the plaster. This may be removed *when dry,* with the aid of a toothbrush.

1

2



3



Figs. 1-5. Steps in the preparation of a latex mushroom model, as described in the text.

After the mushroom is removed, a hole is drilled through the gill side of the plaster and through the bottom of the plaster stem. The liquid latex will be poured through these holes, so allow a diameter of at least 3/8". Place the plaster halves of each set together, with the holes upwards. Masking tape or a rubberband will ensure that the halves remain together to prevent leakage. (Fig. 5)

Pour the latex into the cast until the cavity is filled. Allow it to remain in the cast for several minutes, then pour the excess back into the latex container. Allow the rubber in the cast to dry for at least two hours. Repeat the addition of latex until an adequate thickness of rubber is attained. Prior to the removal of the latex mushroom from the plaster, add a small amount of talcum powder to the cavity. This will prevent any wet spots from sticking together.

Again using your knife, carefully pry the plaster halves apart. Trim away any excess rubber with a pair of small scissors. Join the cap and the stem together by using a small amount of the latex as a glue.

The easy part of the duplicating process will now be completed, for unless you are artistic you may find the painting rather time consuming. Water colors or oils, depending on your preferences, may be used. Several *thin* coats of paint will look more realistic than one thick application.

When you succeed in your painting, a shiny finish to the cap may add a touch of realism. This is accomplished by a *brief* spraying of clear Krylon. If a dull finish is needed, spray with Krylon Matte.

Fig. 6. Several completed latex models of mushrooms.

MICHIGAN PLANTS IN PRINT

New Literature Relating to Michigan Botany

This section lists new literature relating to Michigan Botany under four categories: A. Maps, Soils, Geography, Geology (new maps and selected bulletins or articles on soils and geology as these may be of use to field naturalists and students of plant distribution); B. Books, Bulletins, etc., and C. Journal Articles (listing, respectively, all separate publications and articles in other periodicals which cite Michigan specimens or include research based on plants of wild origin in Michigan;–not generally including work on cultivated plants nor strictly economic aspects of forestry, conservation, or agriculture); D. History, Biography, Exploration (travels and lives of persons with Michigan botanical connections). When the subject matter or relation to Michigan is not clear from the title, annotations are added in brackets. Readers are urged to call to the editor's attention any titles (1960 or later) which appear to have been overlooked–especially in less well known sources.

A. MAPS, SOILS, GEOGRAPHY, GEOLOGY

Lotan, James E., & Stephen G. Shetron. 1968. Characteristics of drumlins in Leelanau County, Michigan. Pap. Mich. Acad. 53: 79-89. [Data on glacial drift.]

Redmond, C. E., & C. A. Engberg. 1967. Soil Survey of Arenac County, Michigan. U. S. Dep. Agr. 142 pp. + 24 twice-folded map plates + [8] folded tables & indexes. [The folded map plates include complete aerial photography for the county at a scale of about 3" = 1 mile, with boundaries of soil types overprinted; hence an indispensible aid for field work in the county. Fieldwork completed in 1954; series numbers are now omitted from Soil Surveys. $2.25 from Govt. Printing Office, Washington, D.C.]

Weber, Herman L., et al. 1966. Soil Survey of Grand Traverse County, Michigan. U. S. Dep. Agr., Series 1958, No. 34. 141 pp. + 92 once-folded map plates + [6] folded tables & indexes. [The folded map plates include complete aerial photography for the county at a scale of about 4" = 1 mile, with boundaries of soil types overprinted. Like the other recent soil surveys which include such photography, indispensible to anyone wanting quickly to survey the wooded and wild areas of the county. $4.75 from Govt. Printing Office, Washington, D. C.]

B. BOOKS, BULLETINS, SEPARATE PUBLICATIONS

Ostrom, Arnold J. 1967. Forest Area in Michigan Counties, 1966. North Central For. Exp. Sta., U. S. For. Serv. Res. Note NC-38. 4 pp. [Includes table with figures for all land, non-commercial, and commercial forest area by counties.]

Ostrom, Arnold J. 1967. Forest Cover Types by Counties, Michigan, 1966. North Central For. Exp. Sta., U. S. For. Serv. Res. Note NC-41. 4 pp. [Includes table showing, for each county, total commercial forest land area (excluding parks and other reserved areas) and acreage in each of 6 major forest types.]

Stone, Robert N. 1967. Forest Stand-Size Trends in Upper Michigan, 1955-1966: North Central For. Exp. Sta., U. S. For. Res. Note NC-39. 2 pp. [Table of acreages based on 1963-1966 survey; general comparisons with 1946-1957 data.]

C. JOURNAL ARTICLES

Bassett, I. J. 1967. Taxonomy of Plantago L. in North America: Sections Holopsyllium Pilger, Palaeopsyllium Pilger, and Lamprosantha Decne. Canad. Jour. Bot. 44: 565-577. [*P. cordata* cited from Lansing and shown at two stations in Michigan on distribution map.]

Catana, A. J., Jr. 1967. Forests of the Harvey N. Ott Preserve. Am. Midl. Nat. 78: 496-507. [Quantitative study in Calhoun Co.]

Laing, Charles C. 1967. The ecology of Ammophila breviligulata. II. Genetic change as a factor in population decline on stable dunes. Am. Midl. Nat. 77: 495-500. [This corrects erroneous citation in Mich. Bot. 7: 28. 1968.]

La Roi, George H. 1967. Ecological studies in the boreal spruce-fir forests of the North American taiga. I. Analysis of the vascular flora. Ecol. Monogr. 37: 229-253. [Based on data from stations across the continent, all Canadian except for one black spruce stand and one white spruce–fir stand in Marquette Co. (located only by latitude and longitude).]

Lewis, Walter H., Royce L. Oliver, & Yutaka Suda. 1967. Cytogeography of Claytonia virginica and its allies. Ann. Missouri Bot. Gard. 54: 153-171. [Chromosome counts for material from Berrien Co. given as 2n = 24, 25, & 26.]

Milanez, Adauto I., & Everett S. Beneke. 1968. New records of aquatic Phycomycetes from Michigan. Pap. Mich. Acad. 53: 11-22. [Records from Kalamazoo and Barry counties.]

Porsild, A. E. 1966. Contributions to the flora of southwestern Yukon Territory. Natl. Mus. Canad. Bull. 216 (Contr. Bot. IV): 1-86. [159 distribution maps generally show no stations beyond Alaska and Canada, except apparently for *Poa canbyi* and *Phacelia franklinii* on Isle Royale.]

Pringle, James S. 1967. The fringed gentians–observations on their life histories in Ontario. Wood Duck 21: 14-17. [Includes observations on Waugoshance Point (Wilderness State Park, Emmet Co., Michigan).]

Roscher, John P. 1967. Alga dispersed by muskrat intestinal contents. Trans. Am. Micr. Soc. 86: 497-498. [13 species of viable algae recovered from cultures from muskrats trapped in Kalamazoo Co.]

Schuyler, Alfred E. 1967. A taxonomic revision of North American leafy species of Scirpus. Proc. Acad. Nat. Sci. Phila. 119: 295-323. [Cites chromosome counts for *S. atrocinctus* (n = 34) from Gladwin Co. and *S. cyperinus* (n = 33) from Cheboygan Co.]

Thomson, John W. 1967. The lichen genus Baeomyces in North America north of Mexico. Bryologist 70: 285-298. [*B. rufus* is cited from Alger and Iron counties and Isle Royale and mapped at these locations.]

Publications of Interest

PICTORIAL HISTORY OF MICHIGAN: The Early Years. By George S. May. William B. Eerdmans Publ. Co., Grand Rapids, 1967. 239 pp. $15.00. Essentially a picture book pertaining to Michigan before the 20th Century; the text is limited to helpful captions. A number of the illustrations are reproductions of old maps, there is a section on "The Age of the Lumberman," and other features of natural history interest are shown. Douglass Houghton is mentioned, as a geologist, but botanists might wish for more about the earliest botanical work in the state (Zina Pitcher, Abram Sager, John Wright are nowhere mentioned). The volume is fortunately well indexed, and is handsomely printed in a large format; it is highly fitting that the printing, typography, and binding were all done in Michigan.

THE LICHENS OF OHIO Part I. Foliose Lichens. By Conan J. Taylor. Biol. Notes 3, Ohio Biological Survey, Columbus, 1967. 151 pp., plastic bound. $5.00 from Mailing Room, OSU, 242 W. 18th Ave., Columbus, Ohio 43210. This work, which should be quite useful in at least southern Michigan, is thoroughly illustrated with 120 photographs of the species, and includes keys, descriptions, maps showing distribution (by counties) in Ohio, and instructions for collecting and studying lichens. There is a checklist (with nomenclatural equivalents) of the lichens of Ohio. Part II, completing the work, is expected within a year.

Review

A FIELD GUIDE TO WILDFLOWERS of Northeastern and North-central North America. By Roger Tory Peterson and Margaret McKenny. Houghton Mifflin Co., Boston. 1968. 420 pp. $4.95.

"For some years we have been looking forward to the promised publication" of this field guide—so we wrote in the very first issue of this journal (p. 44) six years ago! At last, the long overdue volume is out, and it will be warmly welcomed by many wildflower enthusiasts. The illustrations are very good, though the exact shades of the colored ones often leave something to be desired. All grasses, sedges, rushes, and pondweeds are omitted but otherwise the selection is unusually complete for a truly pocketsize book (nearly 1300 species, both native and alien). Inevitably there are points at which one might differ over the selection of species which the average layman "is most likely to encounter." *Hieracium florentinum* is one of the most widespread and conspicuous weeds of roadsides and fields throughout northern Michigan, but it is not included. The thousands of visitors to Michigan's shoreline parks and beaches are surely far more likely to encounter and wonder about such showy plants as *Iris lacustris, Cirsium pitcheri,* and *Anemone multifida* than they are the extremely rare and local orchids *Cypripedium passerinum* and *Triphora trianthophora,* but the latter are included and the former locally common ones are omitted.

A certain impatience with professional botanists is evident, to the point of inaccuracy. Much is made (p. x and p. 90) of the fact that Gleason's New Britton and Brown has but 6 species of *Antennaria* while Fernald's edition of Gray's Manual includes 32; it seems unfair not to add that at least 13 of the latter are reported only from Newfoundland or other portions of Canada specifically excluded from the range covered by Gleason. There is a great amount of useful identification information (some of it a bit subjective) and, as noted, a surprisingly large number of species in this compact guide. It is an excellent buy at $4.95. Having made this point, with emphasis, let me go on to deplore the *arrangement* of this material which might be described as nearly chaotic.

There is no key or outline of any sort whatsoever. The fundamental grouping is by color (not always of the flowers), with subdivisions often headed by such characters as "Loose clusters or sprays of dangling flowers" or "Loose clusters of dangling bells" (the latter for *Prenanthes!*). Surely the vagueness of this sort of terminology is no improvement over the few essential botanical terms. And what would Roger Tory Peterson say about a bird guide arranged by color (of, presumably, adult male plumage); or Roger Conant about a guide based on snake and frog color; or A. B. Klots to a butterfly guide arranged by color? From this standpoint, this number of the Field Guide series is distinctly retrograde. If color is so useful for identification, then why did the authors not simply provide a key based on color instead of technical characters?

The trouble with using color is that it simply doesn't work for too many of the plants. The authors have had to include a great many species under two or more colors, thus consuming valuable space. And there remain dozens of additional species of which white or other color forms are known but which for some reason are not included. Countless internal contradictions could be cited. For example, *Polygonum lapathifolium* is listed only under pink, though said to be "more often greenish white." *Trillum erectum* is included in two places under red and is said to be occasionally "greenish, white, etc.," but it is listed under no other color. *Castilleja coccinea* appears only under red, although the flowers are correctly described there as "greenish-yellow." *Acorus calamus* is shown under both yellow and green, at the latter point said to have "no spathe," although the figure clearly shows the long spathe and the very next sentence refers to the "stem that bears the spathe."

Fortunately there is a list of families with brief diagnoses in the front of the book, each with a silhouette symbol which is rather cleverly done and which, together with family name, appears with the species. So the effect of color-arrangement is somewhat overcome and the reader is likely to gain some understanding of the families after all. Those who do not mind leafing through a couple hundred pages to find related species which differ slightly in color will no doubt be delighted with this otherwise highly recommended volume.

—E. G. V.

PROGRAM NOTES

Sept. 27-29, 1968: Fall Campout, Southeastern Chapter, Michigan Botanical Club. Sleeper State Park is the place.

Editorial Notes

The large size of this and some other issues results from the generosity of authors (and their institutions or grants) who enable us to maintain our editorial policy that all pages in excess of 10 in any article must be subsidized and that subsidy of shorter articles (or of even the first 10 pages of longer ones) encourages prompt publication. Subscription income alone would allow four issues of approximately 32 pages each per year.

Good black and white prints of botanical subjects, suitable for use on the cover of THE MICHIGAN BOTANIST, are always welcome and may be submitted to the editor at any time.

The March number (Vol. 7, No. 2) was mailed March 13, 1968.

Erratum

Vol. 7, p. 89, line 2 from bottom: for "*C. caroliniana*" read *C. virginica.*

Publications of Interest

THE KOMAROV BOTANICAL INSTITUTE. 250 Years of Russian Research. By Stanwyn G. Shetler. Smithsonian Institution Press, Washington, D. C., "1967" [1968]. 240 pp. $5.95, distributed by Random House, Inc. The relevance of this volume to the Great Lakes region is perhaps remote, but those interested in the history of botany, particularly at institutions which emphasize plants of northern latitudes, will find it a welcome alternative to much digging around in the Russian language. This is a popular account, fully illustrated, of the history of a rich tradition of botanical scholarship, chiefly in taxonomy, over two and a half centuries and involving several institutions founded by Peter the Great, culminating in the presentday Komarov Botanical Institute of the Academy of Sciences of the USSR. The history of the monumental 30-volume Flora SSSR is given in some detail, and there is material on the vast library, herbarium (nearly 6 million specimens), and other facilities as well as on the men who built up the Botanical Garden and Botanical Museum which in 1931 were merged into the Botanical Institute: Siegesbeck, Trinius, C. A. Meyer, Regel, Ruprecht, Maximowicz, Komarov, Schischkin, and others.

LIMNOS The Magazine of the Great Lakes Foundation. Vol. I, No. 1, Spring 1968. Published four times a year, included with membership ($5.00) in the Great Lakes Foundation, 2200 North Campus Blvd., Ann Arbor, Michigan 48105. The first number of this new periodical solicits articles and illustrations "dealing with discoveries or advances in our knowledge of the Great Lakes"; and it includes articles on research by submarine in Lake Michigan, water pollution, topography of the floor of Lake Michigan, the coho salmon, and Great Lakes water levels.

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(On the cover: Dune grass, Elymus mollis *Trin., on the shore of Lake Superior at Whitefish Point, Michigan. Photographed July 20, 1967, by John S. Russell.)*

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THE

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Articles and notes dealing with any phase of botany relating to the Upper Great Lakes Region may be sent to the editor in chief. The attention of authors preparing manuscripts is called to "Information for Authors" (Vol. 6, p. 202; reprints available from the editor).

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Membership in the Michigan Botanical Club is open to anyone interested in its aims: conservation of all native plants; education of the public to appreciate and preserve plant life; sponsorship of research and publication on the plant life of the State; sponsorship of legislation to promote the preservation of Michigan native flora and to establish suitable sanctuaries and natural areas; and cooperation in programs concerned with the wise use and conservation of all natural resources and scenic features.

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SEX DETERMINATION IN MOSSES

Dale H. Vitt
Herbarium, The University of Michigan, Ann Arbor

Genetically determined dioecism is one of the mechanisms making cross-fertilization obligatory in plants and animals. In fungi this is accomplished by heterothallism with many species being bipolar, that is, with one set of genes controlling compatability, whereas other species are tetrapolar, with two sets of genes controlling compatability. It has been found recently (Raper, 1966) that in tetrapolar basidiomycetes one set of genes, "aa," controls the formation of clamp connections and a second pair, "bb," controls the migration of nuclei. In the latter case, if fungi containing only the "aa" pair of alleles are mated, clamp connections are formed, but there is no nuclear migration and thus no fertilization.

In many higher plants cross-fertilization and incompatability are determined by a multiple allelic system. If the pollen and the female system contain identical alleles, the pollen tube will not grow.

In accord with these incompatability mechanisms, dioecism may operate at either the haploid or diploid level and thus prevent self-fertilization. Dioecism is under the control of separate systems in haploid and diploid types of organisms (see figure 1). These two types of sex control systems may be distinguished on both genetical and morphological grounds. Haploid dioecism occurs in many algae and bryophytes and diploid dioecism, in many higher plants and animals.

The control of sex and consequently dioecism in some higher plants and most animals is known to be by X and Y chromosomes. In these cases, the males are heterogametic (XY) and the female homogametic (XX). In this type of system the Y chromosome is of considerable importance in determining the phenotype of the individual. However, other mechanisms are known, such as the balance concept of sex in *Drosophila* where the ratio of X's to autosomes determines the sex. If the ratio is below one, then the fly is a male; if it is above one, it is a female. In this case the Y chromosome plays a relatively minor role in determining the phenotype. A third condition is found in some Lepidoptera, birds, and reptiles. If the animal contains XX it is a male, and if the genotype is XO [no Y chromosome] it is a female. Here, then, the heterogametic sex is the female.

In haploid plants, such as bryophytes and algae, the sex mechanism differs from that of diploid plants in that both differential segments always behave as units of heredity. In diploid plants there are two types of combinations possible in the sporophyte generation, the XX and the XY; whereas in haploid plants there is only one type possible, the XY. In diploid organisms the X chromosome undergoes recombination in the homogametic sex; this never takes place in haploid organisms as the X of female plants always pairs with the Y of the male plants.

PHENOTYPIC EXPRESSION OF SEX IN MOSSES

In bryophytes, dioecious species result when spores of two types produce two different plants: the male containing only the Y chromosome and the female containing only the X. This situation is not analogous to those higher plants where a dioecious species is composed of male plants containing XY and female plants containing XX. In bryophytes the XY condition is asexual and not male as in diploid organisms.

Among diploid organisms the differential segment of the Y chromosome never undergoes recombination, and many geneticists regard this as the reason for the erosion and reduction in size of the Y chromosome during the course of evolution. In haploid systems neither the X nor the Y undergoes recombination, and yet the X chromosome is not eroded and reduced in size. From this comparison of evidence, lack of recombination cannot explain the small size of the Y chromosome.

Sex in mosses is shown phenotypically in several ways: (1) structure and position of sex organs on the plant, (2) size of the individual plants, (3) size of spores, and (4) type of gametes produced. The position of the sex organs can be summarized as follows. Plants that are bisexual (fig. 2) are termed monoecious. However, in mosses several different arrangements are possible. If the archegonia and antheridia are in separate inflorescences, but on the same plant, the species is called autoecious (figs. 3-6). Included in this type of arrangement are (a) gonioautoecious (figs. 3, 4, 6), with the antheridia axillary or budlike below the

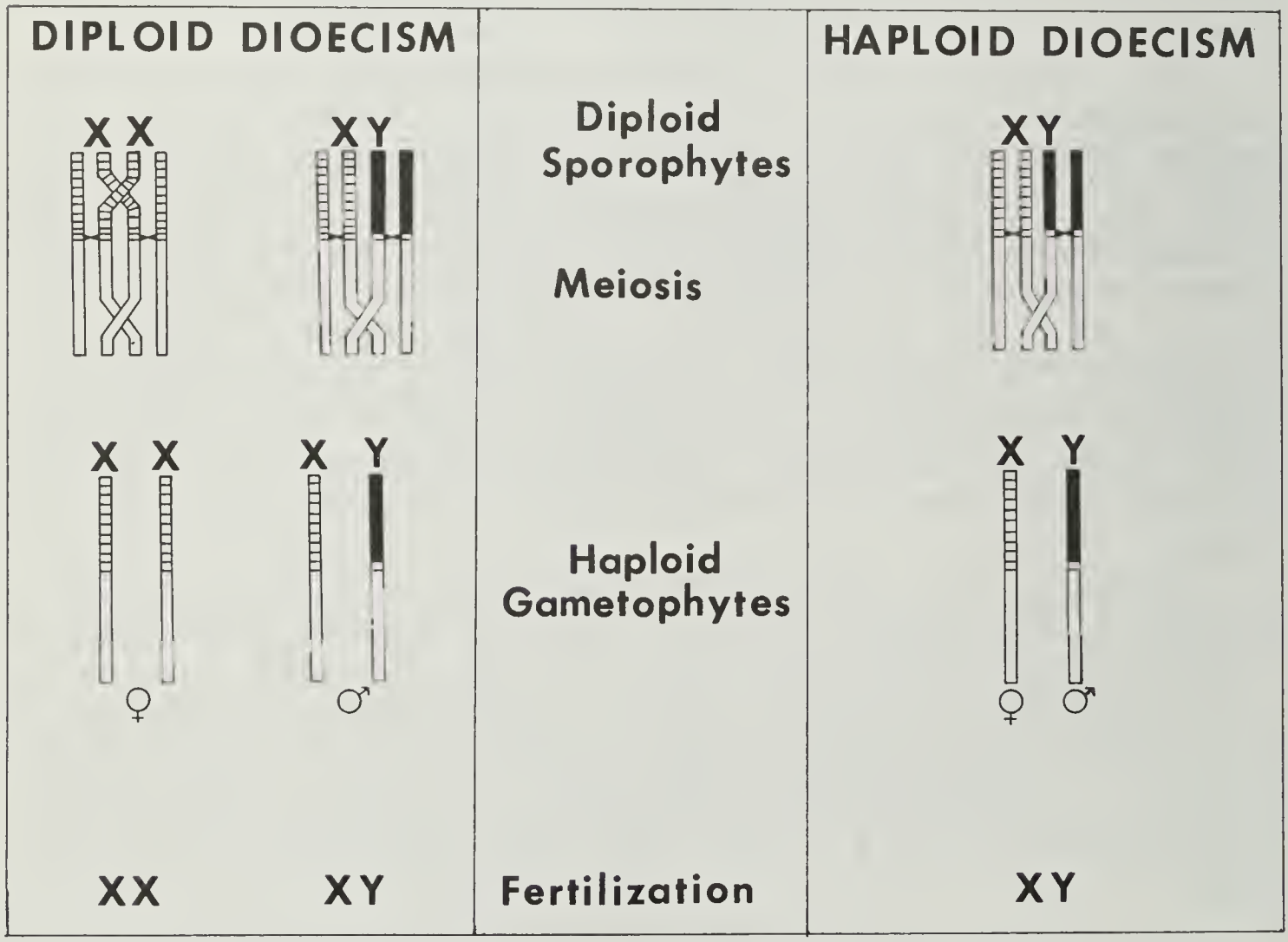

Fig. 1. A comparison of haploid and diploid dioecism. (Modified from Lewis, 1961)

archegonia and (b) cladautoecious (fig. 5), with antheridia and archegonia on separate branches. Many mosses, such as the common *Mnium medium* BSG, have the antheridia in the same inflorescence as the archegonia (fig. 11). If these are mixed together, the term synoecious is used. However, if the antheridia and archegonia are in the same inflorescence but not mixed, the term paroecious is used. Frequently the genera *Polytrichum* and *Atrichum* have antheridia and

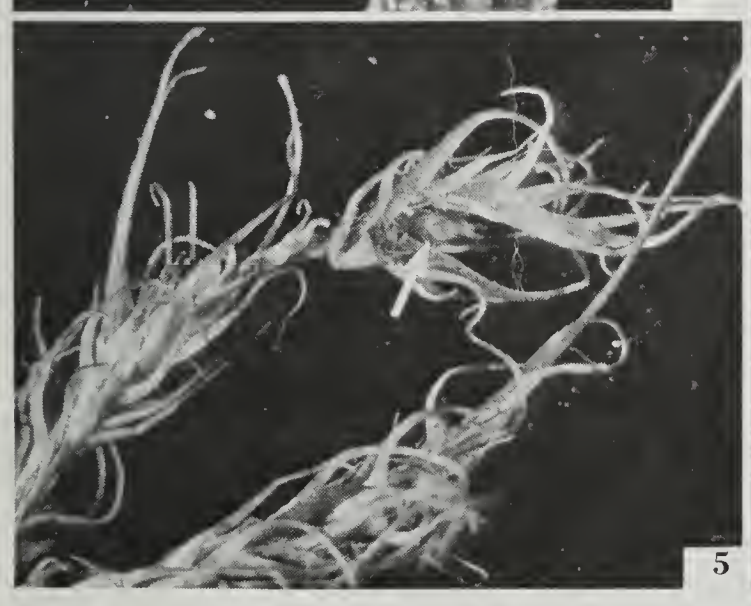

Fig. 2. Monoecious plants with male buds of *Orthotrichum speciosum.* Fig. 3. Gonioautoecious plants of *Drepanocladus* sp. with male buds below seta of capsule. Fig. 4. Closeup of male buds of *Drepanocladus* sp.; the antheridia enclosed within the buds. Fig. 5. Cladautoecious condition of unknown species; male bud on separate branch from female, which is represented by the sporophyte. Fig. 6. Gonioautoecious condition of *Orthotrichum speciosum;* male buds at arrows.

archegonia on the same plant in separate inflorescences and also mixed together; this condition is referred to as polyoecious or heteroecious.

Of more important consideration here are the dioecious species. In some cases, such as *Mnium affine* Bland. *ex* Schwaegr. and *Atrichum undulatum* (Hedw.) P.-Beauv. (figs. 8, 9), the male and female plants are undifferentiated. In *Orthotrichum lyellii* Hook. & Tayl. (fig. 7), the male plants are slightly smaller than the female plants. In some species of *Macromitrium, Holomitrium,* and *Eurhynchium* the male plants are greatly reduced to what are called dwarf males (figs. 10, 12). These are, in fact, very small male plants which grow attached to the stems, leaves, or rhizoids of the larger female plants.

In addition to the above manifestations, many dioecious species, especially in the family Orthotrichaceae, phenotypically express sex in the form of "heterospory" or as will be explained later, anisospory. In this family, which is mainly tropical, there are three large genera, *Orthotrichum, Macromitrium,* and *Schlotheimia,* in addition to a few smaller genera. In this group, anisospory appears to be correlated with a reduction in the Y chromosome and often a reduction in the size of the male plants.

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Fig. 7. Slight sexual dimorphism of *Orthotrichum lyellii* with male plant on right. Fig. 8. Male and female plants of similar size of *Atrichum undulatum.* Fig. 9. Male inflorescence on left and sporophyte arising from female plant on right of *Atrichum undulatum.*

By means of spore counts, size frequency has been obtained for the spores of many species. Figures 13 through 16 illustrate a few of these counts. Species in which there are two sizes of spores show a bimodal peak. In *Macromitrium* there seems to be a distinct correlation between anisospory and the occurrence of dwarf males. The homosporous species of *Macromitrium* are all monoecious, and as seen in figures 13 and 19 their spores are fairly constant in size (compare this with figs. 14, 17, 18, which illustrate anisosporous spores). In *Orthotrichum* there seems to be one dioecious species that has spores of two sizes, namely *O. lyellii* Hook. & Tayl. (fig. 16), whereas at least one other dioecious species, *O. obtusifolium* Brid. (fig. 15), appears to be homosporous.

Thus in mosses there are four types of dioecism:

Homosporous with no morphological dimorphism e.g. *Orthotrichum obtusifolium* Brid.

Homosporous with dwarf males e.g. *Eurhynchium pulchellum* (Hedw.) Jenn.

Anisosporous with slight dimorphism of plants e.g. *Orthotrichum lyellii* Hook & Tayl.

Anisosporous with dwarf males e.g. *Macromitrium* species

However, in no case does anisospory appear with monomorphic dioecious species. This is significant in that both characteristics may be advanced.

HETEROSPORY AND ANISOSPORY

Heterospory can be defined as the production of two sizes of spores by one plant. In all higher plants, the micro- and megaspores are produced in separate sporangia. It follows that all products of a single meiotic division will be

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Fig. 10. Cauline dwarf male on stem of female plant of *Holomitrium* sp. Fig. 11. Synoecious condition of *Mnium medium.*

Fig. 12. Dwarf males of *Eurhynchium pulchellum*.

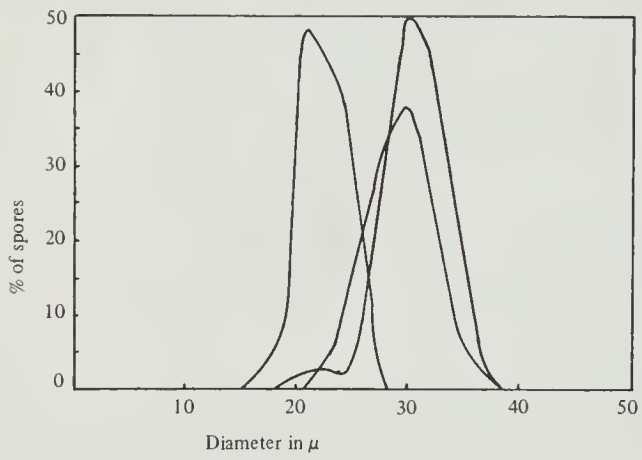

Fig. 13

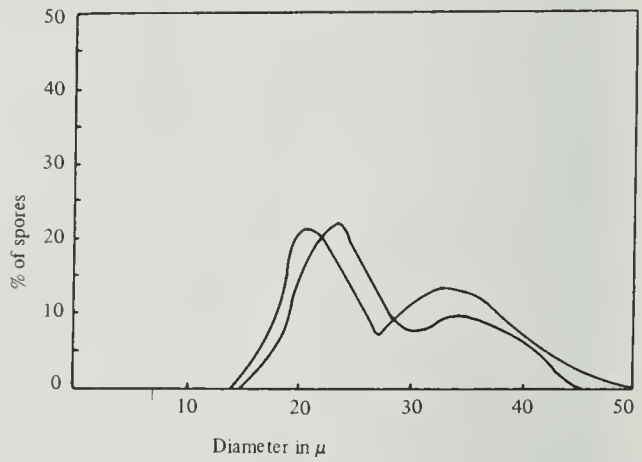

Fig. 14

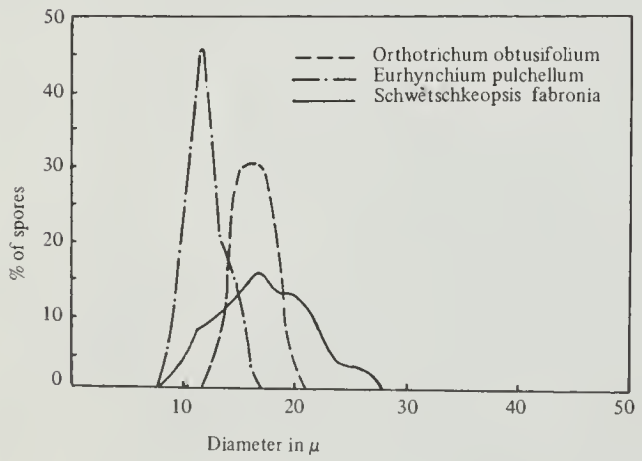

Fig. 15

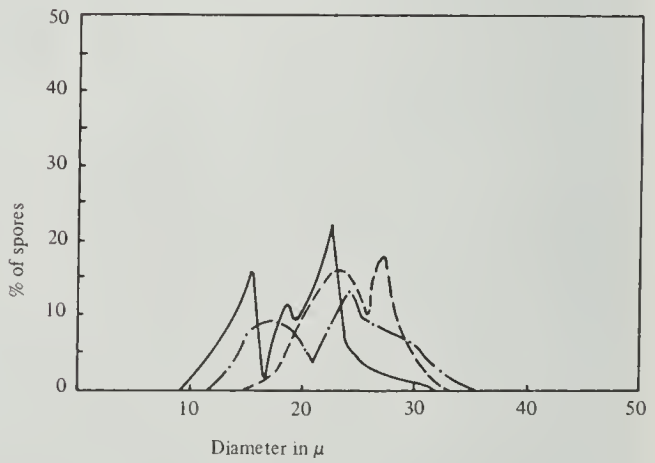

Fig. 16

Fig. 13. Spore size distribution of monoecious (homosporous) species of *Macromitrium (M. ferriei, M. incurvum, & M. holomitrioides)*. Fig. 14. Spore size distribution of dioecious (anisosporous) species of *Macromitrium (M. comatum & M. prolongatum)*. Fig. 15. Spore size distribution of three dioecious species: *Orthotrichum obtusifolium, Eurhynchium pulchellum, & Schwetschkeopsis fabronia.* Fig. 16. Spore size distribution of *Orthotrichum lyellii* from three localities.

all microspores or megaspores. This is the case in the heterosporous species of *Selaginella* and *Isoëtes* as well as the heterosporous Filicales, Marsiliaceae, and Salviniaceae. In all these cases the gametophytes are endosporic.

In mosses and hepatics the micro- and megaspores are produced in the same sporangium and both types of spores result from the same meiotic division, two of the products being microspores and two, megaspores. In no case have sporangia of two sizes been found. Greguss (1964) reported size differences in sporangia of *Fontinalis antipyretica* Hedw. and *Brachymenium mexicanum* Mont.; however, I can find no evidence of size differences in spores or sporangia in these two species. As opposed to the case in true heterospory, bryophyte gametophytes are exosporic. Thus the mechanism of sex and differential spore size, as well as development, is not the same in higher plants as in bryophytes. Since the condition in higher plants is termed heterospory, the condition in bryophytes requires a new term, anisospory.

The above evidence allows speculation that the anisosporous type of spore development could not have given rise to the heterosporous type. Instead it seems probable that the anisosporous species of mosses have evolved parallel to the higher plants with heterospory.

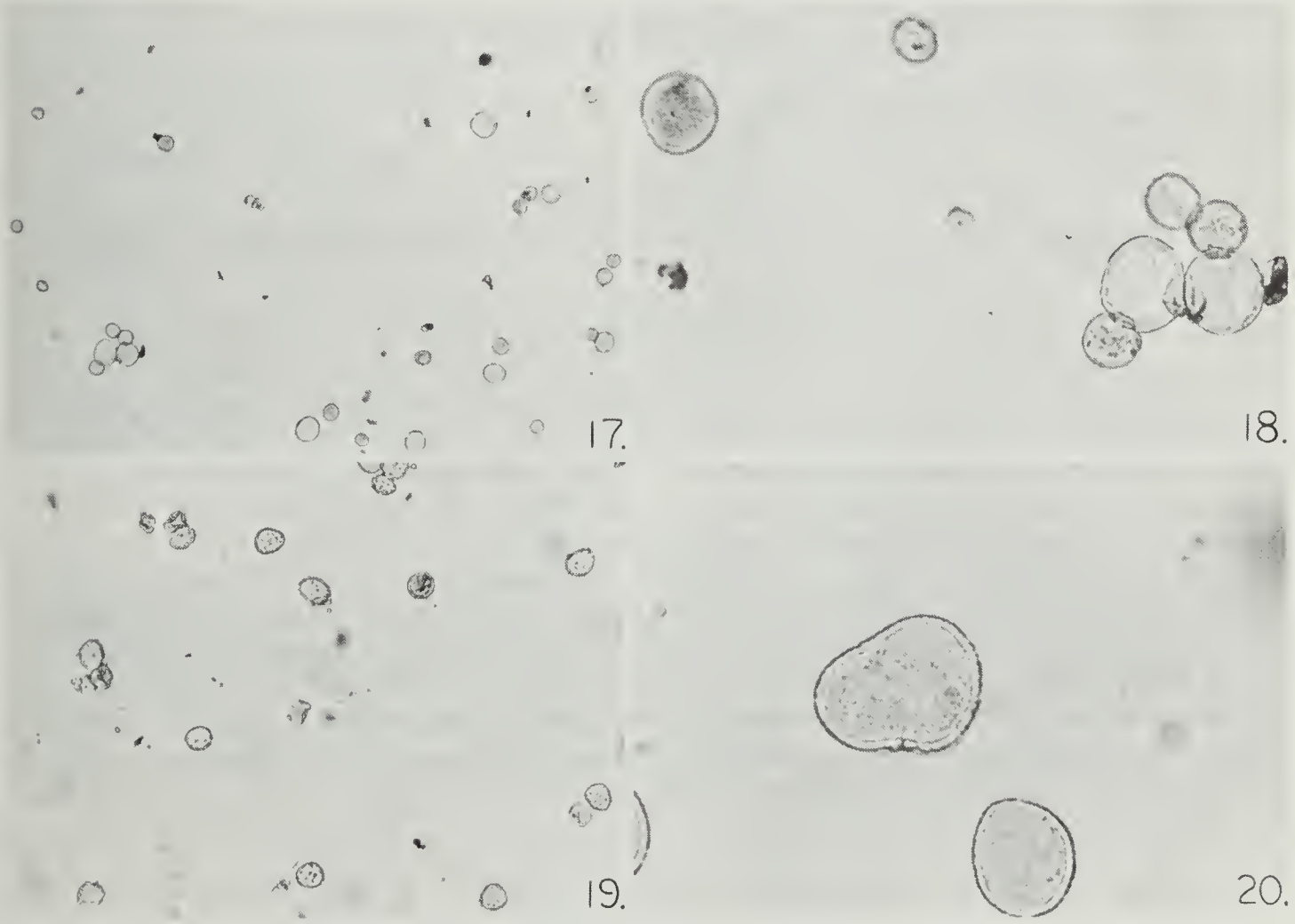

Fig. 17. Spores of *Macromitrium comatum.* Fig. 18. Enlarged view of spores of *M. comatum.* Fig. 19. Spore of *Orthotrichum obtusifolium.* Fig. 20. A probable instance of chromosome doubling (autopolyploidy) in a dioecious species, *Orthotrichum lyellii.*

DIMORPHISM OF SEX CHROMOSOMES

Evidence available at present indicates that dimorphism of spores and male plants is connected with dimorphism of sex chromosomes. In 1909, Douin found that the spores of *Sphaerocarpus* germinate in tetrads giving rise to two male and two female plants in groups. He concluded that sex differentiation takes place in spore mother cell differentiation. Allen (1917), working with the liverwort *Sphaerocarpus donnellii,* correlated a chromosome difference with the dioecism. He found 14 autosomes of equal size and two unequal chromosomes in diploid sporophyte cells. This was the first time that sex chromosomes of any kind were reported. Early workers also found some chromosomes in mosses to be completely heterochromatic. Heitz (1928) called the larger of these the M and the smaller the m. In 1944, Ernst-Swarzenbach concluded that the dioecism of *Macromitrium* was controlled by an XY mechanism. Ramsay (1966) showed by photographs that at the meiotic division of the spore mother cells there is a segregation of a large and a small chromosome which form a dimorphic bivalent at metaphase.

Working with hepatics, Tatuno (1941) termed the large heterochromatic chromosome H and the smaller h. Yano (Anderson, 1964) found that out of 94 dioecious species studied, 90 had only one H chromosome. He has postulated that in monoecious species there are two H chromosomes and that these species are either aneuploids or polyploids. Furthermore, in *Mnium,* Lowry (1948) found that monoecious taxa may originate from dioecious ones by autopoly-ploidy. Heitz (Schuster, 1966) found the following correlations:

Chromosome number	Species studied	Percent Monoecious	Percent Dioecious
n= 9	33	27	73
n=18	14	100 (93)?	0 (7)?

SUMMARY

Evidence indicates that the evolution of sex as a means of out-breeding has evolved in numerous ways. In those organisms which contain sex chromosomes, a relationship exists between heteropycnosis and sex chromosomes. These heteropycnotic chromosomes can best be referred to as H and h chromosomes. Furthermore, in many monoecious species of bryophytes the pairing of these is H/H and h/h, not H/h.

At least in *Macromitrium,* dioecism is associated with morphologically different chromosomes; however, anisospory exists in *Orthotrichum lyellii* with no morphological difference in the sex chromosomes. Some species of bryophytes have two H chromosomes and if these species are polyploids, they are monoecious. This polyploidy may be auto-polyploidy (fig. 20). One can speculate that dioecism is primitive and monoecism is derived from it. In accordance with this, anisospory is probably an advanced character occurring only in species in which polyploidy has not taken place.

ACKNOWLEDGMENTS

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MOSQUITO POLLINATION OF *HABENARIA OBTUSATA* (ORCHIDACEAE)[1]

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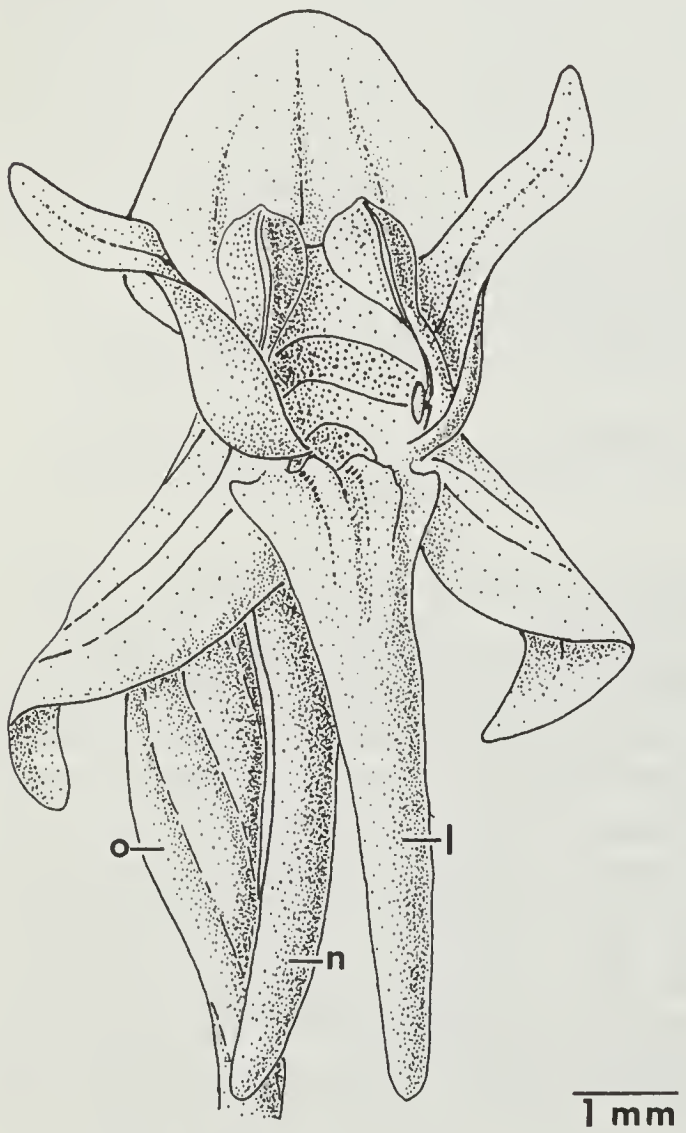
In early July, 1912, Miss Ada Dietz, working in Reese's Bog at the University of Michigan Biological Station (Cheboygan Co., Michigan), saw a mosquito whose head bore two yellow objects resembling pollen masses. This was reported to John Dexter who also visited the bog and captured half a dozen female mosquitoes with from 1 to 4 pollen masses on their eyes. The objects were pollinia of *Habenaria obtusata* (Banks ex Pursh) Richards, which was flowering in the vicinity. Dexter gathered pollen-free mosquitoes and flowering plants of the orchid, enclosed both in an aquarium, and in a few days the insects were carrying orchid pollinia on their eyes in the same position as those caught in the bog (Dexter, 1913). The mosquitoes were not identified and the behavior of the insects on the flowers apparently was not observed. This report of mosquitoes as orchid pollinators was the first of several involving this plant. Specimens of the insects have been observed carrying the pollinia in the Athabaska and Great Slave Lake areas (John W. Thomson, pers. comm.; Raup, 1930), in the vicinity of Churchill (Hocking et al., 1950; Hocking, 1953), and near Bear Lake by

[1]Research supported by NSF grant GB5784X. I wish to thank the members of the Huron Mountain Wildlife Foundation for the use of their facilities during part of this work.

Porsild (Twinn et al., 1948). The identified mosquitoes were all females in the genus *Aëdes*. West and Jenkins (1951) reported that mosquitoes caged with *Habenaria obtusata* containing P^{32} fed on the orchids and became radioactive, but mosquitoes also visited five other species treated with P^{32} (*Salix, Ledum, Rhododendron, Dryas,* and *Rubus* species) and fed on radioactive nectar in these flowers as well.

Many observations of mosquitoes resting or feeding on flowers are recorded in the literature; Hocking (1953) and Haeger (1955) list plants distributed among about 30 plant families. Mosquitoes feed on sugar secretions from both floral and extrafloral nectaries as well as on aphid honeydew. Nectar is an important part of the diet of tundra mosquitoes, 45-95% of the weight of fed insects being due to this (Hocking, 1953). Tropical and subtropical mosquitoes also take flower nectar, and species of the genera *Toxorhynchites (Megarrhinus)* (Jenkins & Carpenter, 1946, Jenkins, 1949) as well as *Liponeura* and *Apistomyia* (Porsch, 1958) have the proboscis so modified that the insects are probably incapable of sucking blood and may rely entirely on other liquids as energy sources. In spite of numerous observations of mosquitoes on flowers, these



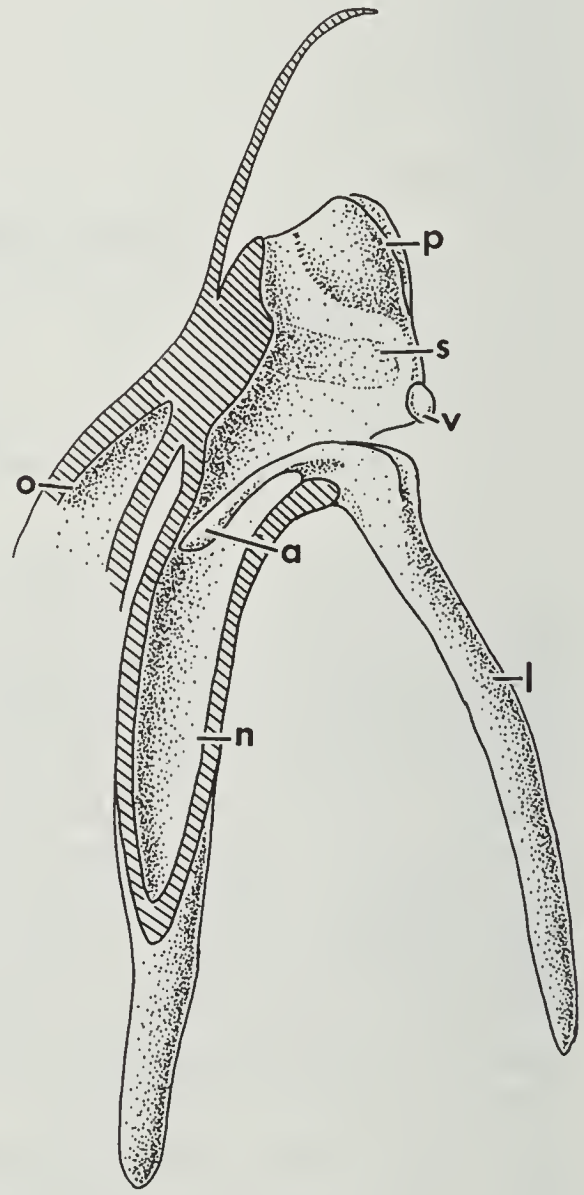


Fig. 1-2. Face and submedian section of *Habenaria obtusata* flower.
1-labellum, n-nectary, o-ovary, a-appendage, v-viscidium of pollinium, p-pollen mass in anther locule, s-stigma.

insects appear to be transient visitors to most flowers and are of little importance as pollen transfer agents. To date we know of only one plant whose pollen has repeatedly been found on mosquitoes and that plant is the subject of this paper.

Habenaria obtusata has a general nearctic distrubution, occurring from Labrador and the New England states westward to the Aleutian Islands and British Columbia. The closely related or conspecific *H. parvula (Platanthera parvula* in European usage), occurring from eastern Siberia to Scandinavia, completes the circumpolar distribution. To my knowledge no insect visitors to the latter orchid have been reported. *Habenaria obtusata* inhabits cool coniferous forest areas where midsummer soil temperatures rarely exceed 15° C. In Michigan it often is rooted in moist humus which may be very wet during the early part of the growing season. Plants also colonize well drained sandy humus under pines and spruce near Lake Superior. Seedlings are subterranean for several months, and then produce a single leaf during the first season of growth above ground. Lateral droppers are produced which give rise to new plants near the parental axis the following season, as is characteristic of most members of this subfamily Orchidoideae. The plants do not form wide-spreading clones as do *H. flava, H. clavellata,* and *Orchis rotundifolia* by the growth of droppers several centimeters away from the parental axis. When plants reach flowering size they usually produce one leaf and a few-flowered inflorescence 10-20 cm in height (Fig. 3). The individual whitish-to-greenish flowers are galeate, with the hood usually held horizontally and the labellum ("lip") pendent or recurved below (Fig. 1). The nectar spurs in Michigan plants are 7-10 mm long, about 5 mm of which contains nectar at the time of anthesis. I can detect no odor to the flowers, although Raup stated that they were scented.

The stigmatic surface is between the 2 half-anthers and directly above the nectary opening (Fig. 2). The base of the labellum bears a ligulate appendage which projects backward, partially closing the nectary lumen. The shape of the appendage and the degree of obstruction differ from plant to plant, and also change as flowers age. Entrance to the nectary is possible from the sides, where canal-like passages are formed between the adjacent walls of the nectary and labellum appendage. The adhesive gland (viscidium) of each pollinium is situated to the side of these canals. An insect inserting its proboscis through one of the canals will contact the adjacent viscidium.

I had the opportunity to observe three flowering colonies of this orchid in Michigan during July, 1967, and to watch for insect visitors. The first observations were made in a *Thuja-Picea* woodland near the shore of Albany Bay, Mackinac Co., on July 3. Air temperature was 12°C between 2 and 4 P.M., and mosquitoes were present in large numbers but lethargic. No insect visitors of any kind were attracted to the 20 plants under observation during this period. The greatest plant feeding activity of mosquitoes in Manitoba (Twinn et al., 1948), in Florida (Haeger, 1955), and in Denmark (Nielsen & Grieve, 1950) occurs before the dusk and after the dawn mating swarms. Twinn observed mosquitoes visiting flowers of *Habenaria obtusata* at dusk but not at other times. This periodic feeding and the low air temperature possibly account for failure to observe the process in the field during this limited period.

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Mosquitoes from this site were collected and caged with inflorescences using a glass box made of 3.5 x 4.5'' slide glasses taped at the edges. The insects, in a room temperature of 20-25°C, alighted on the inflorescences within a few minutes after the 7 PM caging. Two pollinia were removed from flowers before equipment was ready for accurate observation. Several insects were followed through the pollinium removal process during the following hour. An insect alights on any projecting part of the inflorescence but especially on the lateral sepals, rests for an indefinite period ranging from a few seconds to several minutes, and then begins probing the surface of the flower with the proboscis. This probing involves the front and rear surfaces of the sepals and petals, and continues until the insect is perched across the face of the flower parallel to the labellum. At this point the proboscis is directed to the region of the nectary opening. The insect appears to be poorly oriented for finding the nectary and the searching movements appear awkward. The mosquito attempts to force the proboscis into the nectary but is inhibited by the obstructing appendage. When a proboscis is inserted in one of the lateral canals and pushed into the spur (Fig. 4), the compound eye adjacent to the viscidium contacts this structure, and the pollinium is attached either during feeding or as the head is withdrawn. A mosquito maintains this feeding position for a minute or longer before withdrawing from the nectary. The pollinium, attached to an eye, is withdrawn from its half-anther (Fig. 5), and the insect immediately attempts to remove the attached pollinium with one or both front legs. Because of the lateral approach to the nectary only one pollinium is removed per visit. An insect with a pollinium attached to one eye rests for indefinite periods and then visits other flowers. The pollinium projects forward parallel to the proboscis, and inhibits the insertion of the proboscis into other nectaries as it strikes the surrounding structures. Repeated attempts to insert the proboscis usually seem to result in the proboscis being inserted in the opening opposite to the one from which the first visit was made because of the obstructing attached pollinium on that side. Clusters of pollen grains (massulae) are left on the stigmatic surface during the probing movements or during the insertion of the proboscis in the alternate opening. Several insects removed two pollen masses, one on each eye, after several hours of confinement with the inflorescenes (Fig. 6). Dexter found mosquitoes carrying 3 or 4 pollinia, but insects observed in this study removed a maximum of 2. The presence of one or more pollinia on a mosquito appears to increase its searching and probing activity on flowers. This increased activity also

Fig. 3. Natural stand of *Habenaria obtusata.* Plants are 13-16 cm tall.

Fig. 4. *Aëdes intrudens* inserting proboscis in nectary

Fig. 5. *Aëdes* after feeding, with freshly attached pollinium on right compound eye.

Fig. 6. *Aëdes* with two pollinia.

Fig. 7. Resting *Aëdes* with 2 pollinia. Viscidium can be seen attached to lower part of compound eye.

increases the chances of pollen massulae being left on stigmas with concomitantly increased setting of fruit.

A small collection of mosquitoes flying in the study area were identified as *Aëdes intrudens, A. canadensis,* and *A. fitchii.*[2] Of 36 specimens examined, 1 carried a pollinium but was unfortunately lost before identifications were made.

A collection of approximately 100 mosquitoes was made in another colony of *Habenaria obtusata* growing in a *Thuja* bog near St. Martin's Point, Mackinac Co. The flying insects were *Aëdes vexans, A. fitchii,* and *A. intrudens,* of which 1 of *A. vexans* carried a pollinium on the lower side of the left compound eye. A collection of similar size was made in a *Tsuga-Thuja* bog near Conway Creek, Marquette Co., on July 17 after most of the orchids had ceased flowering. *Aëdes intrudens, A. diantaeus, A. canadensis,* and *A. fitchii* were flying, and one female of *A. intrudens* or *diantaeus* carried a pollinium on its right eye. (The specimen cannot be precisely identified because females of these two species are very difficult to separate.) Two to 3 hours were spent at each of these bogs watching for visitors during daylight hours. Mosquitoes were active but not visiting the orchids.

Flowering plants of *Habenaria obtusata* were brought to Akron, Ohio, well south of the range of the species, and females of *Aëdes intrudens* were captured locally. These were caged with the orchid, and within a few minutes an insect was probing a flower and shortly removed a pollinium. Of 10 insects caged, 4 removed 6 pollinia from an inflorescence over a 12-hour period. One was attached to a left eye, one to a right eye, and 2 insects carried pollinia on both eyes. Mosquitoes from populations which never come in contact with this orchid were attracted to it and functioned in a normal manner.

DISCUSSION

Species of *Aëdes* have long been known to visit and to remove pollinia from *Habenaria obtusata* but no other insect visitors to the orchid have so far been recorded. The labellar appendage appears to be a morphological adaptation to insects with the general head dimensions of mosquitoes, and the species seems to be unique among flowering plants in this regard. It appears strange that close associations between other plants and mosquitoes have not been reported in view of the prevalence of both mosquitoes and flowering plants in all the temperate land masses. Such associations may well exist but perhaps have not yet been observed because Culicine research has been largely anthropocentric. The physical discomfort attendant on mosquito-flower studies under natural conditions also tends to inhibit observation.

Mosquitoes are relatively primitive dipterans; compared with many other groups of this order they are inactive and spend much of their time resting on vegetation or in protective cavities. Their slow movements when alighted and their long legs with short hairs suggest that they are inefficient carriers of the non-sticky types of pollen. They are present in large numbers in many habitats, however, and additiional plant-mosquito relationships can be expected.

[2]Mosquito identifications by Dr. Carl Venard, Ohio State University, whose assistance is gratefully acknowledged.

A considerable amount of information is available concerning mosquito feeding stimuli. Airborne factors activating mosquitoes include rise in temperature, increase in CO_2, increase in moisture, and presence of volatile organic compounds (Clements, 1963). Mosquitoes are very sensitive to temperature changes, especially in the range of 29-30°C, and can detect and react to a temperature gradient of 0.05°C/cm (Bates, 1949). Some of the dipteran-attracting heavy textured Araceae have a considerable temperature rise at anthesis (Meeuse, 1966) but this is thought to be associated with volatilization of attracting compounds rather than as an attracting mechanism in itself. The immediate reaction of mosquitoes to warmth might serve either as a short-range attractant or in orienting them on a flower. It is highly unlikely that the small and thin textured flowers of *Habenaria obutsata* could produce enough temperature rise to attract the insects, because of the very rapid thermal radiation from the flower and the accompanying very high respiration rate required for an effective temperature rise. Very small temperature changes in the thicker tissues of the center of the flower could serve to orient the mosquito in front of the column, however, and flowers should be examined with this in mind.

Chemical mosquito attractants have been intensively investigated, and of the many compounds tested, one consistently initiates feeding reactions. Carbon dioxide-air mixtures from such diverse sources as burning candles, human breath, and gas cylinders induce mosquitoes to fly upwind and to orient themselves in relation to the source of carbon dioxide (Wright, 1968). Carbon dioxide is one of the respiration products of plants, and it is possible that the flowers of *Habenaria obtusata* have capitalized on this as a short-range feeding stimulant. Mosquitoes become more active as relative humidity increases and local addition of water vapor to the air may also affect feeding responses of mosquitoes on the flowers. The orchids grow on the forest floor, often in very humid places, or about the sides of depressions where *Sphagnum* and *Rhodobryum* mosses abound. The relative humidity in such areas is consistantly higher than on the surrounding higher ground. Local addition of more water vapor in such habitats would seem to be an ineffectual feeding stimulant. Little can be said of the volatile organic compounds which attract biting mosquitoes, since most of the work done with mosquito-attracting compounds involves animal skin secretions or their byproducts. The flowers have little or no odor detectable to me, but organic compounds may be produced to which mosquitoes react.

Mosquito reactions to color are equivocal, but the insects generally prefer surfaces of low reflectivity. If *Aëdes* visits to *Habenaria* usually take place in the dim light of dawn or dusk in an already heavily shaded environment, flower color probably is of little importance to the insects. These flowers are white to light green in color and are not differentiated from their surroundings in this respect.

Repeated observation of mosquitoes in forested areas of northern Michigan and adjacent Ontario indicates that insects spend much of their time clinging to vegetation, especially the undersides of leaves, to thin stems of herbs, and to any convenient projecting object. The erect inflorescence of *Habenaria obtusata* seems eminently suitable for such perching behavior, with its radially

projecting flowers, each of which provides convenient footholds. Mosquitoes are always plentiful in the vicinity of flowering plants and can be expected to alight on the projecting inflorescences as a matter of course. Short range orienting mechanisms could come into play after such contact. Limited observation of the behavior of caged insects in the laboratory suggests that this may be the case. Female mosquitoes perched on flowers for indefinite periods before starting the probing reaction. This is very different behavior from their direct attack and feeding on mammals.

Flowers of *Habenaria obtusata* are modified in two respects which appear to represent adaptations to mosquito pollinators. The first is a short nectary which is compatible, lengthwise, with the mosquito proboscis; and the second is the labellum appendage at the entrance to the nectary. Other North American species of *Habenaria* also bear calli on the face of the labellum, but they are further from the nectary orifice, and the flowers are either larger in size or appear to have internal dimensions incompatible with those of mosquitoes. Hocking et al. (1950) reported twice seeing mosquitoes feeding on *Habenaria hyperborea* (L.) R. Br. flowers, but pollinia were not removed. In some flowers of this species the labellum at anthesis does not separate completely from the galea but remains curved forward and upward as the flower expands. This produces two lateral openings in the flower, one over each viscidium. Plants vary in the degree of flower opening; the labellum in some becomes more or less completely expanded and straight. The degree of opening in some plants also increases as flowers age. The partially opened flowers of *Habenaria dilatata* (Pursh) Hook. must also be entered laterally. *Habenaria dilatata* bears white and very fragrant flowers and is visited and pollinated by Hymenoptera and Lepidoptera, pollinia being attached to the visitor's proboscis. The green or cream colored flowers of the odorless or ill-smelling *Habenaria hyperborea* have shorter nectaries than *H. dilatata* (3-7.5 vs. 5-10 mm) and appear to be of the proper size for mosquito visits. I have never seen insects on the spikes of this species, although colonies have been watched. Pollinia can often be found attached to sepals and petals and to surrounding vegetation, where they have obviously been detached by visitors. The visitors have not been identified, but the restricted lateral opening of the flower, the dull color, and the short spur suggest that mosquitoes could be effective pollinators. The pollinium length of *Habenaria hyperborea* (1.5 mm) is the same as that for *H. obtusata.*

Pollinia attached to weak fliers, such as *Aëdes* species, may inhibit movement of the insects. Fresh insects were not weighed during the investigation but the average weight of 3.11 mg given for unfed *Aëdes communis* (Hocking, 1953) can be used as an approximation of the weight of *A. vexans,* which is of similar size. The average individual weight of 10 *Habenaria obtusata* pollinia (refrigerated for 9 months in sealed vials in this laboratory) is 0.06 mg. On this basis each pollinium attached to a visiting *Aëdes vexans* will add about 2% to the weight of the insect. This appears to be very little in comparison with the 45% and greater weight increase which a freshly fed insect supports in flight. The position of the pollinia on the eyes may have considerably greater effect than their weight, however. One or two such bulky objects, projecting forward near

the antennae may radically change the maneuverability of flying mosquitoes. We do not know whether they in any way shorten the life of the insect, but they do interfere with feeding at other *Habenaria* flowers.

All identified pollinia-carrying mosquitoes have been females. Twinn made several collections in the Churchill area and found from 2 to 33% of the female mosquitoes captured carried pollinia. Hocking (1953) gives some very high percentage figures for female mosquitoes which are presumed to have visited *Habenaria obtusata,* the figures increasing from less than 10% shortly after flowering begins to over 70% 25 days later. These derived figures are based on reasoning given in the 1950 paper (p. 76-77). Most mosquitoes netted in man's vicinity will have a higher percentage of females than is normal for the population, and this may erroneously suggest a preponderance of female mosquitoes carrying pollinia. It is probably significant, however, that neither Hocking, Twinn, nor I have found pollinia on male individuals which were also present. Male mosquitoes bear much larger antennae than females, and these structures may constitute a mechanical barrier to effective penetration of the flowers by males. Carbon dioxide, warmth, and increase in relative humidity all stimulate female mosquitoes to bite but the effect of these changes on male mosquitoes has not been reported. The orchid flowers may attract and/or stimulate only female insects. If this is the case, it is unusual because male mosquitoes visit other flowers, no sexual selection being operative.

If other mosquito attracting flowers are discovered, they may exhibit an association of characters similar to the ones present in this orchid. Bright color appears to be of little significance. Nectar will be produced or suggested and, if present, will be within proboscis-reach of the insect. The flowers may be odorless and they may be held on erect or spreading peduncles which are in the flight path of mosquitoes. The flowers may be relatively small. Such plants will be most likely to occur in mosquito-rich habitats and plants with these attributes should be examined for possible mosquito adaptation.

ADDENDUM: Since this article went to press, Mrs. F. W. Case observed a population of the Geometrid moth *Xanthorhoe munitata* Hubner (det. J. H. Newman) in the vicinity of *Habenaria obtusata* plants in Big Creek Swamp, Crawford Co., Michigan. Two moths captured on flowers of the orchid carried pollinia on their eyes in the same position as the objects are attached to *Aëdes* mosquitoes. An assessment of the role played by Geometrids requires more observation and should be a sanguine endeavor.

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STUDIES ON THE HYDNUMS OF MICHIGAN. I. GENERA *PHELLODON, BANKERA, HYDNELLUM*

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The University of Michigan Herbarium contains an outstanding collection of the hydnums of North America. Its foundation was laid by C. H. Kauffman while making his studies of the Agaricaceae of Michigan and since has been greatly enlarged through the collections made by A. H. Smith. In the last two years I have had the opportunity to study these collections. This is the first of two papers based on them and gives keys and descriptions for the identification of all genera and species found to date in the state with details on a few species that can be expected when collecting is expanded into counties not explored as yet. Hydnums are exacting in their growth requirements and many kinds fruit only in restricted areas, or during favorable seasons after long intervals of time. It takes years to build up the necessary collections for even a modest flora of any region and this makes the yearly records from Michigan uniquely valuable. It is hoped that this paper will stimulate interest in these rare fungi so that additional favorable collecting areas can be located and a more complete understanding of the requirements of the species obtained. It is of interest to point out that the distributions given in these papers are the most complete for any comparable area in North America but the more common species have been recorded from only 10 of the 83 counties in the state. In the paragraphs on material examined, the collections cited are from Michigan unless otherwise stated.

KEY TO GENERA OF THE HYDNACEAE sensu lato

1. Sporophores resupinate only. (Genera not included in this key, but check the following for resupinate forms of some pileate species.)
1. Sporophores stipitate, pileate or composed of branched tubercles with long teeth hanging from the branches, some species with resupinate forms 2
2. Lignicolous or on cones 3
2. Terrestrial or on rotted woody material or duff 7
3. Sporophores ungulate, perennial, woody, on conifers . . . . . *Echinodontium*
3. Sporophores not ungulate, annual 4
4. Sporophores pileate-resupinate, spores non-amyloid . . . . . *Steccherinum*
4. Sporophores pileate or tuberculate-branched, spores amyloid 5
5. Sporophores on cones usually of *Pinus* spp., stipe eccentric, hairy* . . . . . *Auriscalpium*
5. Sporophores on logs or living trees 6
6. Sporophores branched and branches with spines or spines hanging from a central fleshy mass of tissue, flesh amyloid in part at least . . . . . *Hericium*
6. Sporophores conchate, pileate or resupinate . . . . . *Gloiodon*
7. Sporophores small (-4 cm), context soft, cottony, concrescent, hymenium on blunt spines or folds, spines not terete in cross section; spores white in a deposit . . . . . *Sistotrema*
7. Sporophores usually over 4 cm, context fleshy fibrous, firm to fragile, hymenium covering spines; spores brown or white in deposit 8
8. Spores brown 9
8. Spores white 10
9. Context fleshy, firm to fragile, growth determinate . . . . . *Hydnum*
9. Context tough, fibrous, growth indeterminate . . . . . *Hydnellum*
10. Context tough, fibrous, growth indeterminate . . . . . *Phellodon*
10. Context fleshy, firm to fragile, growth determinate 11
11. Spores smooth . . . . . *Dentinum*
11. Spores echinulate . . . . . *Bankera*

**Beenakia* Reid, a somewhat similar genus from Australia and New Zealand, grows on tree ferns and has brown non-amyloid spores.

PHELLODON Karst., Rev. Mycol. 3 (9): 19. 1881. Medd. Soc. Fauna Fl. Fenn. 6: 15. 1881.

Calodon Quél. *in* Cke. & Quél., Clav. Hymen. 196. 1878, pro parte.

Basidiocarps terrestrial, arising from a tomentose pad, pileate and stipitate. Hyphal system monomitic, hyphae colored or with walls containing dark pigment granules, septate; septa without clamp connections. Spines decurrent, subulate, terete in cross section, context of parallel hyphae densely packed. Spores subglobose, hyaline, echinulate.

Type species: *Phellodon niger* (Fr.) Karst.

Quélet and Cooke in 1878 proposed the genus *Calodon,* characterized by a fibrous context and containing species with both white and brown spores, but did not validate it with a description. *Phellodon* Karsten (1881) was proposed for hydnums with white spores and spines regardless of consistency of the context. Later in 1881 Karsten accepted *Calodon* Quél. in place of his own genus and validly published it. *Phellodon* as originally described was well defined, has priority, and is generally accepted. The spores have ornamentation in the form of very fine processes. In the North American species studied, these processes

appear to be pointed but as there are 15 to 16 on the circumference of a spore 4 μ in diameter, it is almost impossible to verify this without the aid of an oil immersion lens.

KEY TO SPECIES OF *PHELLODON*

1. Pileus strongly zonate . . . . . 3. *P. tomentosus*
1. Pileus not strongly zonate 2
   2. Stipe slender, usually under 4 mm in diam 3
   2. Stipe stout, usually over 4 mm in diam. 4
3. Pileus brownish black, spines stain brownish on bruising, amyloid-like inclusions occurring in surface hairs . . . . . 2. *P. melaleucus*
3. Pileus bluish black, spines stain blackish on bruising, no amyloid-like inclusions observed in surface hairs (not found in Mich.) . . . . . *P. atratus*
   4. Spines not over 2 mm long, pileus tomentose, tan, becoming gray and finally brown, flesh not black and hyphae not dark in Melzer's reagent . . . . . 4. *P. confluens*
   4. Spines up to 4mm long 5
5. Pileus deep purplish black when young, black to brownish in age; flesh and surface hyphae dark in Melzer's reagent. . . . . 1. *P. niger* var. *niger*
5. Pileus whitish when young to dark brown in age; flesh dark but surface hyphae not dark in Melzer's reagent . . . . . 1. *P. niger* var. *alboniger*

1. *Phellodon niger* (Fries) Karst., Rev. Mycol. 3: 19. 1881. var. *niger.*

Hydnum nigrum Fries, Syst. Myc. I: 404. 1821.
Hydnellum nigrum Karst., Medd. Soc. Fauna Fl. Fenn. 5: 41. 1879.
Calodon niger Quél., Ench. Fung. 191. 1886.

Pileus: 5-7.5 cm broad, often concrescent, convex when very young, becoming plane and finally depressed, often scrobiculate on discs especially when pilei are fused; surface velvety to strigose, tomentose, or tomentum matting in age, pallid gray, becoming violet-black to dark brownish gray in age at the center, margin thick becoming thin, light gray. Context duplex, upper layer soft and concolorous with surface, lower layer and context of stipe firm, black; no odor; taste mild; when dried with the odor of fenugreek (sweetly fragrant).

Spines: 2.5-4 mm long, light gray, darker when bruised.

Stipe: Variable depending on depth of duff, 2-6 x 0.5-3.0 cm, several arising from a common pad of mycelium, grayish, with a thick coating of mycelial felt that may surround several stipes.

Chemical reactions: Not tested fresh. KOH turns context blue-green and the dark incrusting granules in the hyphae dissolve, the pigment leaching into the solution. The granules are black in both water and Melzer's reagent.

Spores and Hymenium: Spores 4.2-5 x 4.2-4.7 μ, globose, subglobose, echinulate, apiculate, white in mass. Basidia 30-35 x 5-5.3 μ, clavate, sterigmata 3.5 μ long.

Tramal features: Surface layer of hyphae 3.2-4.5 μ, dark because of numerous incrusting granules, loosely interwoven, inner layer of hyphae 3.2-4.5 μ, parallel, with a heavy coating of granules; hyphae of spines 2.5-3.2 μ, parallel, sparsely branched from below septa.

Habit, Habitat, and Distribution: Solitary, gregarious, or cespitose and often concrescent, in mixed woods of conifers and hardwoods - often found along with var. *alboniger*. It is known in Michigan from Alger, Washtenaw, and Emmet Counties. We know of one collection from Wyoming and one from Manitoba. It is generally found eastward to the Atlantic seaboard in Canada and the United States.

Material examined: Mains Sept. 1, 1932. Harding Aug. 1, 1949. Smith Oct. 8, 1931, Oct. 10, 1934, 33080, 38677.

Discussion: In the herbarium the surface hyphae of var. *niger* show amyloid-like granules whereas these are lacking in similar hyphae of var. *alboniger*. For further comment see var. *alboniger*.

Phellodon niger var. *alboniger* (Peck) K. Harrison, Stip. Hyd. N. S. 22. 1961. Figs. 1,2.

Phellodon alboniger (Peck) Banker, Mem. Torrey Bot. Club 12: 167. 1906.
Hydnum albonigrum Peck, Rep. N.Y. State Mus. 50: 110. 1897.
Calodon alboniger (Peck) Seeler, Rhodora 44: 168. 1942.

Pileus: 3-9 cm broad, convex to plane or sometimes depressed, surface tomentose to smooth, grayish white with the center gray, soon becoming dull brownish; margin thick, blue gray, becoming thin and lighter, soft and taking a fingerprint readily under pressure, darker when bruised. Context duplex, upper layer pale dull brown or concolorous with surface layer, in the stipe firm and black; odor slight at first, strong when drying; taste mild to slightly acrid.

Spines: 2.5-4 mm long, stout, light grayish, decurrent, sometimes in cool weather arranged concentrically.

Stipe: 4-10 x 1-2 cm, light brown becoming dark brown, felted, bulbous, lower part up to 3 cm thick from a water-absorbing layer of mycelium.

Chemical reactions: Not tested fresh; with Melzer's reagent showing dark incrusting granules coating the hyphae in the darker layers of the pileus and stipe, some of the hyphae next to the dark layer show incrusting granules, hyphae of the surface layer smooth; KOH turns flesh blue-green and the incrusted granules dissolve producing a dark olivaceous color.

Spores and Hymenium: Spores white in mass, globose to subglobose, mostly 4.5-5 μ, a few 4.5-5.3 x 4.5-5 μ, coarsely echinulate, prominently apiculate. Basidia 25-30 μ, long, 5.3-6.4 μ wide, clavate; sterigmata up to 4.2 μ long, no clamps seen at base.

Tramal features: Hyphae in surface layer 4.2-5.3 μ, loosely interwoven, with slightly colored walls; hyphae of inner layer 3.2-4.2 μ, incrusted with dark granules; hyphae of the spines 2.1-3.2 μ, some with heavy dark granules, branched from immediately below the septa.

Habit, Habitat, and Distribution: Solitary to gregarious or finally concrescent, in sandy pine woods, aspen-pine woods, or in mixed hardwoods, throughout the state. Collections have been examined from Emmet, Livingston, Washtenaw, Oakland, Chippewa, Luce, Cheboygan, Jackson, Keweenaw, and Presque Isle Counties. It occurs generally in eastern North America and is also known from Europe.

Material examined: Kauffman Sept. 2, 1905; Oct. 4, 1907. Mains 6584. Harding 225, 277, 306. Povah 339. Thiers 4120. Shaffer 2789. A. H. Smith 32-315, 1128, 7200, 18494, 18528, 18730, 18744, 20629, 21151, 32650, 32744, 33054, 33083, 35900, 36181, 38077, 38416, 38619, 39319, 39690, 42369, 42407, 42538, 42636, 62846, 63981, 63994, 64196A, 64197, 67742.

Discussion: The differences between var. *niger* and var. *alboniger* are more quantitative than qualitative. The young basidiocarps of var. *alboniger* are lighter in color than those of var. *niger* and when mature are dark brownish instead of dark gray. Also in var. *alboniger* the basidiocarps are usually larger, the surface is more irregular and is rarely depressed. A study in culture of these two varieties would be highly desirable.

2. *Phellodon melaleucus* (Fries) Karst., Rev. Myc. 3: 19. 1881.

Hydnum melaleucum Fries, Syst. Myc. 1: 406. 1821.
Hydnum delicatum Schweinitz, Syn. N. Am. Fung. 161. 1834.
Phellodon ellisianus Banker, Mem. Torrey Bot. Club 12: 174. 1906.
Phellodon delicatus (Schw.) Banker, Mem. Torrey Bot. Club 12: 173. 1906
Phellodon brunneo-olivaceus Coker & Beers, Stip. Hyd. East. U. S. 28. 1951.
Phellodon brunneoroseus Snell, Dick, & Jackson, Lloydia 19: 171. 1956.

Pileus: 1-6 cm broad, or broader when in concrescent groups, plane or disc depressed and rough, sometimes with pileoli, appressed fibrillose, appearing zonate when moist but on drying azonate, color pale to dark violaceous brown fading to very pale violaceous brown in age, margin light grayish drab. Context thin, soft, fibrillose, zonate, nearly azonate when faded, cinnamon drab, darker if wet; odor none; taste mild.

Spines: 1-1.5 mm long, irregularly decurrent on stipe, close, grayish drab becoming dull drab, sordid brown when bruised.

Stipe: 3-6 x 0.2-0.6 cm, compound and rooting, uneven and rough, dark violaceous brown, cinnamon-drab (dull violaceous) above, dark vinaceous brown in the base; pseudorhiza carbonaceous, very uneven and up to 10 cm long.

Chemical reactions: KOH on context dark olivaceous.

Spores and Hymenium: Spores 4-5 μ, white in mass, globose to subglobose, finely echinulate, apiculate. Basidia 25-30 x 4.5-5.5 μ.

Tramal features: Hyphae (2) 3-4 (5) μ broad, in Melzer's reagent no reaction in the spines or flesh, but in the surface hairs and in some of the hyphae next to the hairs a slight apparent-amyloid reaction present.

Habit, Habitat, and Distribution: Gregarious to concrescent in large masses, under conifers. I have seen two collections from Michigan, Smith 38618 and 43111. There are scattered records from the Carolinas to Canada but it is most abundant in the north and particularly in the Pacific Northwest.

Discussion: This is a small species that has the strong fragrant odor of most *Phellodon* species when dried. It grows in deep humus and recurs year after year in the same spot. When wet and growing rapidly it is black with a white margin. The long black pseudorhiza are not often seen as they are very brittle and easily lost when the specimens are collected.

The stipes are sometimes branched. Harvey (1958) describes the development of the branched stipes of *Auriscalpium vulgare* Fries and his observations on the process in that species are probably the best explanation of what happens during the growth of *P. melaleucus*. He found that stipes may be retarded by lack of moisture after they start to grow, then new branches may develop later until finally one produces a pileus. Careful observations on sporophores developing in a locality over a number of years to verify this supposition are needed.

3. *Phellodon tomentosus* (Fries) Banker. Mem. Torrey Bot. Club 12: 171. 1906. Figs. 3,4.

Hydnum tomentosum Fries, Syst. Myc. I: 405. 1821.
Hydnum coriaceo-membranaceum Schw., Trans. Am. Philos. Soc. 2. 4: 162. 1834.
Phellodon cyathiformis (Schaeff. ex St.-Amans) Karst., Rev. Mycol. 3: 19. 1881.
Calodon cyathiformis (Schaeff. ex St.-Amans) Quél., Ench. Fung. 191. 1886.
Hydnum graveolens subzonatum Peck, Bull. N. Y. State Mus. 75: 24. 1904.

Pileus: 1-6 cm broad, often pitted on disc, typically zonate, plane but usually depressed to umbilicate at the center; surface radially fibrillose, streaked, sepia to light brown, pallid to vinaceous buff on margin, when wet dark brown in center; margin wavy and often elevated, thick, tomentose when actively growing. Context 1-1.5 mm thick, pliant, leathery, more or less light brown; odor faint to slightly fragrant of fenugreek as basidiocarps dry; taste mild or slightly sweetish with a slight biting reaction in the throat.

Spines: Up to 2 mm long, decurrent to a line, crowded, pliant, white, shaded with buff in age, staining vinaceous-buff when bruised.

Stipe: 2-5 x 0.2-0.5 cm, often flattened, zonate, irregular in shape, expanding into the pileus, arising from a felty layer of mycelium in the duff, concolorous with pileus, unpolished. Context fibrous, zoned, some duff included in base.

Chemical reactions: When fresh KOH blackens surface and flesh, the margin darkens slightly; $FeSO_4$ grayish on disc then black, flesh grayish. Not reacting when dried.

Spores and Hymenium: Spores white in mass, 3-4 μ, globose to subglobose, finely echinulate, apiculate; basidia 20-25 x 4-5.3 μ, 4-spored, sterigmata 3.5-4 μ.

Tramal features: Hyphae of pileus about 4 μ, thin-walled, septate; in the stipe up to 6.3 μ, and with thicker walls, branches rarely seen.

Habit, Habitat, and Distribution: Gregarious to cespitose and often forming extensive concrescent patches or arcs under conifers. In Michigan it is known from the Upper Peninsula, and from Emmet County below the Straits of Mackinac. It occurs generally throughout conifer areas in northern regions throughout North America and Euope.

Material examined: Smith 38617, 43655, 63984, 64017.

Discussion: This species has thin, strongly zonate basidiocarps rather variable in many of the other characters. Two North American color variations have been given names but since no correlated microscopic differences have been found, they are both included here under the one species.

4. *Phellodon confluens* (Pers.) Pouz., Česká Mykol. 10: 74. 1956.
Fig. 5.

Hydnum confluens Pers., Mycol. Europ. 2: 165. 1825.
Hydnum amicum Quél., Grevillea 8: 115. 1880.
Calodon amicus (Quél.) Quél., Compt. Rend. Assoc. Fr. Av. Sci. 12: 504. 1884.
Hydnum vellereum Peck, Rep. N. Y. State Mus. 50: 110. 1897.
Phellodon vellereus (Peck) Banker, Mem. Torrey Bot. Club 12: 168. 1906.
Phellodon amicus (Quél.) Banker, Mycologia 5: 62. 1913.

Pileus: 4-7 cm broad, concrescent in masses up to 11 cm wide, rarely plane, usually depressed, but often complicate with ascending pileoli, very irregular, surface conspicuously velvety, pallid to creamy buff to grayish or grayish buff, becoming dull brown to dark brown where the pubescence wears off of the older parts; margin even to lobed, sterile, white becoming fuscous to dark brown where bruised. Context duplex, with a soft cottony upper layer concolorous with surface, and a firmer dark lower layer with zones, dark brown when bruised, taste mild to disagreeable, odor of rotting wood combined with fenugreek (phellodon odor) when dried.

Spines: 2-3 mm long, decurrent, side view violaceous gray, tips pallid violaceous gray, dark vinaceous brown in age.

Stipe: Up to 2.5 cm long, usually fused, central or eccentric, very irregular, with a spongy layer around base, concolorous; context central core firm, zonate, brown.

Chemical reactions: KOH darkens both layers; $FeSO_4$ both layers olivaceous; dried material inert in KOH.

Spores and Hymenium: Spores 4.3-4.7 (-5.3) x 3.7-4.2 (-4.5) μ, white in mass, subglobose, echinulate, strongly apiculate. Basidia 25-30 x 4.2-6.4 μ, 4-spored, sterigmata slender, 3.5 μ long.

Tramal features: Hyphae of pileus without clamps, 3.8-5.7 μ broad, thin walled, in outer layer loosely interwoven, abruptly compacted inward, in stipe the same as in pileus but tending to be more nearly parallel and with fewer interspaces.

Habit, Habitat, and Distribution: Gregarious in deciduous or mixed woods, frequently associated with aspen. It is rare, in part perhaps because it matures and collapses much more quickly than the other species in this genus and hence is not as frequently collected. It has been found abundantly in a few areas however. In Michigan it is known from Cheboygan, Emmet, Gratiot, Livingston, Oakland, and Washtenaw counties.

Material examined: Potter 3901, 10013, 10036, 11111. Kauffman 1074, and Aug. 15, 1915. Mains 5308, 6593, 8154, July 15, 1915. Smith 32-323, 1127, 6854, 6874, 6879, 6949, 7096, 7157, 7181, 7287, 10971, 15207, 18464, 18481, 18504, 18544, 18551, 18742, 18750, 20555, 62816, 62832, 63898, 64108, 64196, 64238.

Discussion: This species has had a long history involving many names indicated in the synonymy. It resembles *P. niger* var. *alboniger* to some extent but can be distinguished at once by the lack of a dark inner layer of the context.

BANKERA Coker & Beers ex Pouzar, Česká Mykol. 9: 95. 1955.

Bankera Coker & Beers, Stip. Hyd. East. U. S. 33. 1951.

Sporophores terrestrial, pileate, mesopodus, context thick, fleshy, brittle throughout, nearly white when fresh, not duplex or zonate in texture or color; spore deposit pure white; spores subglobose, minutely tuberculate or subechinulate.

Type species: *B. fuligineo-alba* (Schmidt ex Fries) Pouz.

This genus, but without a Latin description, was published by Coker & Beers (1951) for *Hydnum fuligineo-album* which is distinguished by its brittle flesh and white subspiny spores. Pouzar validated it by publishing the Latin description. The genus is small, with two species in North America, and bears the same relationship to *Phellodon* in the echinulate white-spored group that *Hydnum* does to *Hydnellum* in the brown-spored.

KEY TO SPECIES OF *BANKERA*

1. Pileus glabrous but surface layer soft and debris adhering to it conspicuously . . . . . *B. fuligineo-alba*
1. Pileus glabrous to scaly and surface not holding debris conspicuously . . . . *B. carnosa*

1. *Bankera fuligineo-alba* (Schmidt ex Fries) Pouz., Česká Mykol. 9: 96. 1955. Fig. 6.

Hydnum fuligineo-album Schmidt, *in* Kunze and Schmidt, Mykol., Hefte I: 88. 1817.
Hydnum fuligineo-album Schmidt ex Fries, Syst. Myc., I: 400. 1821.
Hydnum fragile Fr., Sv. Vet-akad. Forh. 1851: 51. 1852.
Sarcodon fuligineo-albus Schmidt ex Fr., Quél., Enchir. Fung. 189, 1886; Fl. Myc. 447. 1888.
Sarcodon reticulatus Banker, Mem. Torrey Bot. Club 12: 139-140. 1906.
Hydnum virginianum Murr., Bull. Torrey Bot. Club 67: 276. 1940.
Hydnum reticulatum (Banker) Lloyd, Letter 54, Note 224. 1915.

Pileus: 6-13 cm broad, convex, becoming plane to depressed or in age umbilicate, surface unpolished, water-soaked in rainy weather, when dry with adhering debris partly due to growth of surface hyphae binding the debris to the surface, rarely diffracted scaly, disc dull dark brown progressing through light brown to fawn and to vinaceous fawn to the margin, much darker when wet; margin incurved, sterile when young, fertile in age, lobed and wavy. Context

brittle to slightly fibrous, tan to vinaceous buff, azonate, when fresh the odor and taste not distinctive, when dried the odor distinctive (as in most species of *Phellodon*).

Spines: 3-5 (-8) mm long, slightly decurrent, close, white becoming pallid, pinkish on young specimens when dried.

Stipe: 2-4 x 1-3 cm, smooth, unpolished, concolorous with pileus, lightest in color next to the spines. Context fibrous, pale vinaceous-buff, fawn or tan.

Chemical reactions: Inert to KOH and Melzer's reagent when dried, not tested when fresh.

Spores and Hymenium: Spore deposit white; spores 4-5 (-6) x 4-5 μ, subglobose, coarsely echinulate. Basidia about 40 x 5.5 μ; sterigmata 3-4 μ, close, no clamps seen.

Tramal features: Hyphae of context 4-6 μ, thin-walled, not clamped, interwoven; hyphae of pileus cutis stain heavily in phloxine and are strongly bibulous.

Habit, Habitat, and Distribution: Solitary to scattered or widely gregarious, usually under pine. In Michigan it is known from Chippewa, Luce, Marquette, and Midland Counties. It is known in addition from Oregon, Washington, North Carolina, Tennessee, Virginia, New Jersey, and New York in the United States and in Canada from Nova Scotia.

Material examined: Bartelli 252. Smith 35833, 38424, 38496, 67761, 67788.

Discussion: This is usually larger and stouter than *B. carnosa* and the disc of the pileus tends to yellow-brown or vinaceous brown rather than the grayish tones of *B. carnosa.* The pileus of the latter is more likely to become lacerate or diffracted scaly. The surface of the pileus in *B. fuligineo-alba* has much debris adhering to it and the cutis is very absorbent-taking up water instantly. *B. carnosa* has neither of these features.

2. *Bankera carnosa* (Banker) Snell, Dick, & Taussig, Lloydia 19: 174. 1956. Figs. 7,8.

Phellodon carnosus Banker, Mycologia 5: 65. 1913.
Hydnum carnosum (Banker) Trotter, Syll. Fung. 23: 472. 1925.

Pileus: 3-10 cm broad, depressed, plane or lobed and wavy; surface at first smooth, unpolished, matted fibrillose, diffracted or lacerate scaly in age, scales small and appressed especially on small fruit bodies; color grayish brown, dull brown to dark brown in age, whitish to pale fawn on the margin. Context soft, sissile, pallid to light brown, not zonate; odor faintly fragrant, strongly fragrant when dried, taste mild.

Spines: 5-6 mm long, decurrent, fairly close, white to pallid, becoming pinkish buff or slightly sordid.

Stipe: 3-6 x 1-2 cm, smooth becoming lacerate scaly, darker than pileus, base darker or occasionally blackened in old specimens; context at apex as in the pileus, harder downward, browner to dark umber at base in age.

Chemical reactions: KOH turns dried context pale olivaceous, fresh material not tested.

Spores and Hymenium: Spores 4-5.5 x 4-5 μ, white in mass, subglobose, coarsely echinulate, hyaline in KOH and Melzer's reagent; basidia 35-40 x 4-4.5 μ.

Tramal features: Hyphae in pileus 4-6 μ, interwoven, not clamped, phloxine did not differentiate a layer of bibulous tissue in the cuticle.

Habit, Habitat, and Distribution: Solitary, gregarious, to cespitose under conifers, widely distributed but generally rare. In Michigan it is known mostly from around Douglas Lake in Cheboygan County. In Canada it is common in Nova Scotia and also known from New Brunswick, Quebec, and British Columbia. Kauffman found it in Oregon and the author found it in the Sangre de Cristo Mountains of New Mexico.

Material examined: Bigelow Aug. 21, 1953. Povah Sept. 4, 1927. Smith 33170, 35946, 37298, 39373, 42514, 63012, 64032, 72165, 75033.

Discussion: The species under discussion here and considered identical with *Phellodon carnosus* Banker has never been observed as pure white but only as pallid to "pale avellaneous." The type collection of Banker's at New York Botanical Garden and Coker's material at the University of North Carolina appear identical with the dried young stages of this species from Nova Scotia, where it has been possible to follow the development of the fruit-body from small stipes to expanded pilei. The young stages are smooth but may become fibrillose scaly if conditions are too dry and later become infundibuliform and lacerate scaly toward the center, a condition most common in western collections. Also as they get older they become dark and badly tunnelled by insect larvae.

This species attains its maximum size in Nova Scotia, Quebec, and northern Michigan. There are no typical well-grown fruit-bodies of this species in the herbaria of Coker or Banker. The occurrence of this species in Europe is still considered doubtful although recently Maas Geesteranus placed it in synonymy under *Bankera mollis* (P. Karst.) Maas G., largely because Banker stressed the white color of *B. carnosa* when young and Fries speaks of the graying of the pileus though his *H. molle* (pl. 2 upper fig. in Icon. Sel. Hym. 1: 4. 1867) is expanded with a thin margin characteristic of fully grown hydnums. Fortunately there is in the herbarium at Michigan a collection from Lundell: *"Hydnum violescens* A. & S. ex Fr. among mosses in boulder strewn spruce woods. Upland: Borge parish, 'Klista skog' (near Upsala) 8 IX 1941." This consists of four pilei, three very light colored depressed and lacerate at the center and one much darker. All have been lightly pressed when dried but not too much to hide the characters. The dark specimen is identical with mature specimens of *B. carnosa* as known in this country. The light colored ones, however, are too light even for very young material of *B. carnosa.* There can be little doubt that three of these specimens are *B. violescens.* The color changes to green in KOH, a character stressed by Maas Geesteranus (1958) and possessed by both. However, it is also apparent that the darker member of this collection cannot be separated from *B. carnosa* of America. The light color of the majority of the specimens and the

Friesian illustration seem to make it necessary to maintain a white species as *H. molle,* and we cannot agree with forcing the wood-brown American species into synonymy with it on the evidence available. It would appear from the Lundell collection that there definitely is a light colored form in Sweden and that at times there is a darker form as well. At this stage they should both be maintained as distinct taxa, at least until the situation as regards the distinctive characters can be evaluated by more detailed studies on adequate fresh material.

HYDNELLUM Karst., Medd. Soc. Fauna Fl. Fenn. 5: 41. 1879.

Calodon Karst. pro. p., Rev. Mycol. 3 (9): 20. Jan. 1, 1881.

Basidiocarps terrestrial, arising out of a mycelial pad, thin to stout, solitary to gregarious or connate; regular to irregular in outline or complicate; context tough, fibrous, zonate, often duplex, upper layer soft, lower layer more compact; spines brown at maturity; spores brown, angular, subglobose, coarsely or finely tuberculate.

Type species: *H. suaveolens* (Scop. ex Fries) Karst. (selected by Banker).

The genus *Calodon* as used by Quélet and Karsten contained the hyaline spored species treated in this paper under *Phellodon* and *Bankera.* Miller and Boyle (1943) accepted *Calodon* but had very few species for study. Coker and Beers (1951) were the first to recognize three genera. The white echinulate spores of *Phellodon* and *Bankera* are easily recognized, and the odor is very distinct in dried specimens in all members of both genera. It is harder to separate the slightly fibrous context of some *Hydnellum* species from the fleshy context of some *Hydnum* species. *Hydnellum* species usually have zonate flesh, a character that has been seen in only one *Hydnum.* The zones are a record of periods of high and low humidity usually associated with the higher humidity at night and give a fairly accurate record of daily growth. (52 bands were counted in one fruit body of *Hydnellum suaveolens* in 1964.) Hydnellums also have an indeterminate habit of growth and are able to expand and grow around small sticks, grass blades, ferns, and pine needles. There are also numerous fusions between adjacent pilei so that mature fruit-bodies may have several stipes and be almost any shape with quantities of foreign material imbedded in the flesh.

The following key is for the hydnellums found in Michigan, but three which are extralimital are included as it is highly probable that these species, commonly occurring in Canada, will be found along the shores of Lake Superior. These are *H. peckii, H. geogenium*, and *H. mirabile.* They are easily recognized. Several other rare eastern species with bluish spines and apparently restricted ranges have been omitted although it is possible they will be found in the northern coniferous forests of the Upper Peninsula.

KEY TO STIRPES OF *HYDNELLUM*

1. Basidiocarp with bluish zones in stipe or pileus context, or on surface of pileus or on teeth at least when young . . . . . Stirps *Caeruleum* (p. 224)
1. Not with above colors 2
   2. Pileus surface strigose; stipe with a watery yellowish juice . . . . Stirps *Mirabile* (p. 242)
   2. Pileus and stipe not as above 3

3. Pileus bright yellow when young; basal mycelium (and that in the duff) yellow . . . . . Stirps *Geogenium* (p. 241)
3. Colors not as above 4
   4. Longitudinal section of basidiocarp and/or pileus surface showing orange to orange brown, rusty orange, or pinkish-orange tones . . . . Stirps *Aurantiacum* (p. 226)
   4. Lacking rusty orange to orange tints 5
5. Context of fresh basidiocarps brittle to subfleshy; never with red droplets on pileus . . . . . Stirps *Humidum* (p. 223)
5. Context coriaceous to semi-woody; red drops often present when fresh 6
   6. Stipe conspicuously felted by a thick soft layer of mycelium . . . . . Stirps *Spongiosipes* (p. 232)
   6. Stipe not with a conspicuous soft outer layer or zone 7
7. Taste burning acrid and persistent in the throat; KOH not giving a blackish reaction on mature tissue . . . . . Stirps *Peckii* (p. 235)
7. Taste mild to farinaceous; KOH blackening mature tissue . . Stirps *Scrobiculatum* (p. 235)

Stirps *Humidum*

1. *Hydnellum humidum* Banker *in* White, Bull. Torrey Bot. Club 29: 553. 1902. Figs. 10-12.

Pileus: 3-12 cm broad, broadly infundibuliform to depressed, surface pubescent becoming appressed fibrillose, zonate, matted fibrillose, with "pinkish-buff" zones more or less alternating with "tawny" to "russet" zones, pileoli sometimes forming in the depressed centers; margin pubescent, obtuse becoming thin, discoloring to dull brown where handled. Context fleshy, soft, thin, not duplex, becoming fibrous, zonate with dark brown lines and with areas between near "wood-brown," unchanging when cut; odor of freshly cut flesh faintly pungent, taste becoming acrid and disagreeable.

Spines: Up to 3 mm long, fine, close, decurrent, "Verona-brown" to "warm sepia" with the lighter tips giving a pallid sheen, frequently fused at the bases to form ridges or a network.

Stipe: 1-4 x 1-2 cm, solid, very irregular, frequently fused, unpolished and dull vinaceous-rusty brown where free of decurrent teeth, often enlarged; context zoned, darker than in the pileus, semi-woody.

Chemical reactions: Hyphae of all parts of the fruiting body reviving poorly in KOH or Melzer's; no color reactions in dried material from either. When fresh, the surface olive-black in KOH, olive grayish in $FeSO_4$.

Spores and Hymenium: Spores 4.5-5.5 (-6.5) x 4-4.5 (-5.5) μ, in mass wood-brown, subglobose, finely tuberculate with 8 or 10 processes on the circumference; basidia could not be revived and sterigmata were not seen.

Tramal characters: Hyphae of the teeth 3-4 μ, flexuous, parallel, occasionally branched; hyphae of the pileus mostly 5-7 μ with a few larger cells, intricately interwoven. No clamps were seen and branching was from below the septa.

Habit, Habitat, and Distribution: Gregarious in low oak woods in Michigan and the eastern seaboard of North America.

Material examined: Smith 6853, 7097, 7197, 7549, 18751, 64248, 64404, 64368.

Discussion: The appearance of these collections fits Coker and Beers' (1951) description closely but they vary in having a strong odor and acrid taste. Banker's original description calls for a tawny to light yellowish brown, scrobiculate, minutely pubescent species, but Coker felt certain his specimens were the same as Banker's. In the herbarium this species is easily confused with *Hydnum stereosarcinon,* but the latter has small oblong, nodulose spores which are distinct from the subglobose finely tuberculate ones of *H. humidum.*

This is a rare species but in 1961 Dr. A. H. Smith made three collections in Michigan and obtained detailed field notes on the fresh material. From these collections it is evident that *H. humidum* is intermediate between *Hydnum* and *Hydnellum* in all characters except those of determinate and indeterminate growth. *H. humidum* has flexuous hyphae forming the thick edge of the pileus margin and growth will proceed indefinitely when conditions are favorable. For this reason it has been decided that *H. humidum* should be left in *Hydnellum.* The flesh of the young plants is softer than in *H. stereosarcinon* but the system of zonations is often similar. However, the tramal cells are thin-walled, interwoven, and somewhat inflated so that the flesh is similar to that of some species of *Hydnum.*

Stirps *Caeruleum*–Key to Species

1. Odor of fresh specimens sickening-sweetish; stipe context and surface typically violaceous but surface fades to pallid. . . . . 2. *H. suaveolens*
1. Not as above 2
   2. Freshly growing areas of pileus blackish when rubbed . . . . . (4. *H. ferrugipes*)
   2. Freshly growing areas of pileus and of teeth typically bluish and not turning blackish when rubbed. . . . . 3. *H. caeruleum*

2. *Hydnellum suaveolens* (Scop. ex Fries) Karst. Medd. Soc. Fauna Fl. Fenn. 5:41. 1879.

Hydnum suaveolens Scopoli, Fl. Carn. 2: 472. 1772.
Hydnum suaveolens Fries, Syst. Myc. I. 402. 1821.
Hydnum boreale Banker *in* White, Bull. Torrey Bot. Club 29: 553. 1902.
Hydnellum rickeri Banker, Mycologia 5: 201. 1913.

Pileus: 4-15 cm, convex to plane, surface tomentose, soft, irregular, uneven, often pestle-like when very young (may develop pileoli with spines at the center), sordid white changing slowly to snuff-brown at center and gradually outwards to the white margin, occasionally thin and lobed; margin with broad sterile band. Context fibrous, thin to thick, zoned with violet – brightest in stipe; odor strongly fragrant; taste mild or slightly cinnamon-like.

Spines: Up to 5 mm long, crowded, fine, "avellaneous" and becoming "wood brown" with "army brown" base (pale to dark vinaceous brown).

Stipe: 3-5 x 1-2.5 cm, woody, interior zoned with "dark madder blue" bands, surface tomentose with a bright violet shade that darkens on being rubbed.

Chemical reactions: KOH stained the violet tomentum on the stipe a blue-green and a trace of the same shade appeared when the colored flesh was tested. Melzer's reagent has no effect.

Spores and Hymenium: Spores 4.5-6.5 x 3-4 μ, vinaceous brown in deposit, oblong, angular, irregular and unevenly shaped, coarsely tuberculate. Basidia 16-20 x 5-6 μ, clavate, 4-spored.

Tramal characters: Hyphae of spongiose layer 4-5 μ in diameter, clamped, thin to about 2.5 μ thick, complexly interwoven, ends of hyphae forming a loose trichoderm (tomentum); hyphae of the more compact inner layer up to 5-7 μ wide, but often very thin, collapsing but reviving well in water followed by 3% KOH; in water strands of dark blue hyphae evident, these hyphae turning greenish in KOH, and then slowly fading; in Melzer's reagent these hyphae are seen to be incrusted with very fine granular material that gives them an "apparent-amyloid" appearance, and in section the granules are coarse as seen under oil immersion lens; hyphae thin-walled and with frequent clamps at the septa, often branched near the septa. Hyphae in teeth 3-4 μ in diameter, parallel, clamped and with fine incrusting "apparent-amyloid" granules.

Habit, Habitat, and Distribution: Scattered, gregarious, occasionally in arcs, under conifers; primarily a northern and montane species. Found from New Mexico to British Columbia in the west and along the Applachians from North Carolina into Canada in the East. Reported as common in the Upper Peninsula but no collections have been deposited in the herbarium.

Discussion: This species is normally thick and stout but in regions of high rainfall and humidity it is thin, expanded and very rough with some of the blue of the flesh showing through on the disc. It also may develop projections that develop as pileoli with spines bearing a hymenium and spores. The youngest stage of this species is a small cushion of violet colored mycelium that develops a white colored apex which enlarges and becomes the stipe and fruit body. This is in contrast to *H. caeruleum,* whose primary cushion is straw-colored and whose developing apex is bluish.

3. *Hydnellum caeruleum* (Hornem. ex Pers.) Karst., Medd. Soc. Fauna Fl. Fenn. 5:41. 1879.
Figs. 9 & 13.

Hydnum caeruleum Hornemann, Flora Danica VIII, fasc. 23: pl.1374.1808.
Hydnum suaveolens Scop. var. *caeruleum* Fries, Syst. Myc. I: 403. 1821.
Hydnum caeruleum Pers., Myc. Europ. 162. 1825.
Hydnum cyaneotinctum Peck, Bull. Torrey Bot. Club 30: 98. 1903.
Hydnellum cyaneotinctum (Peck) Banker, Mem. Torrey Bot. Club 12: 164. 1906.

Pileus: 3-11 cm broad, convex, plane, sometimes depressed, surface smooth, or irregular to colliculose, cottony tomentose, finally matted and pitted; color light blue when young, becoming almost white, gradually darkening in age to dark brown, staining ferruginous when bruised. Context duplex; upper layer spongiose; lower layer tough, fibrous, compact, buff, zonate with bands of mauve and brown, shading to a reddish brown to ferruginous in the lower part of the stipe; taste and odor not distinctive.

Spines: 3-5 mm long, decurrent, close, fine, those on the margin whitish with a shade of blue, finally dark brown with lighter tips.

Stipe: 2-4 x 1-2 cm, base bulbous from felty mycelium, buff colored; context duplex, outer layer thin, inner layer orange or reddish, lighter parts frequently with bands of blue, tough and fibrous; the thick felty layer around the base often disappearing from being eaten by slugs.

Chemical reactions: The blue flesh turns blue-green in KOH and the reddish parts a dull "dark olivaceous," a greenish shade shows in the teeth both young and old, and a dark olivaceous color diffuses out of teeth and flesh into the liquid. In Melzer's reagent reddish incrusting granules are seen adhering to the hyphae, and "apparent-amyloid" hyphae and particles have been seen.

Spores and Hymenium: 4.5-6 (7) x 4.5-5 μ, colored, subglobose, coarsely tuberculate, vinaceous brown in deposit. Basidia 6-7 μ wide with long sterigmata (up to 4.5 μ), 4-spored.

Tramal characters: Upper layer of spongiose tissue with hyphae 3-5 μ in diameter, slightly incrusted in places, frequently branched and loosely interwoven, only one clamp seen after lengthy examination, occasional short section of a hypha showing blackish incrustations in both water and Melzer's reagent. Lower layer of compact hyphae 3-4.5 μ wide, tending to be parallel, tubular, rarely with clamps at the septa, heavily incrusted with reddish brown granules and quantities of fine granular debris present, some sections of hyphae show blackish granules in both water and Melzer's; some granules dissolve in KOH and the hyphae appear greenish. The hyphae in the teeth appear amyloid in Melzer's but when crushed out to a thin layer the blackish color of the walls is diluted and the blackish granules on the walls give the "apparent-amyloid" effect.

Habit, Habitat, and Distribution: Gregarious to concrescent under conifers, often under *Pinus* spp., late summer and fall. It is relatively common in the Upper Peninsula, and in northern conifer areas of North America and Europe.

Material examined: Bartelli 233. Imshaug 3452. Mains 6527. Povah 1240. Thiers 4328. Shaffer 2557. Smith 1129. 32895, 33086, 33087, 33088, 38528, 38664, 39368, 42637, 42639, 58017A, 62853, 63985, 64027, 72004, 72319, 73311, 74517, 74851.

Discussion: The fruit body develops from an ovoid buff colored cushion of mycelium that becomes the bulbous base of the stipe. At first the stipe is apparent as a bluish outgrowth that elongates for 1 or 2 cm and then starts to expand to a convex pileus. It is very compact and solid at this stage. As it matures it is a squat species that shows bluish shades only on the parts actively growing. The color is brighter in cool weather. The species is recognized by the thick, bright colored, blue-zoned flesh of the pileus and the reddish brown color of the stipe. Old specimens become quite brown, others may be brown at the center shading to a blue or pallid margin. This is the result of secondary growth. Fruit-bodies persist for a month or more. Aged specimens are easily confused with *H. pineticola* K. Harrison but can be separated by examining the context.

Stirps *Aurantiacum* – Key to Species

1. Pileus thin and infundibuliform at maturity, not distinctly zonate . . . . . 8. *H. conigenum*

1. Pileus convex to shallowly depressed; context relatively thick 2
   2. Spines with sulphur yellow tips when young; pileus surface more or less smooth but often complicate or with only a few pileoli . . . . . 7. *H. earlianum*
   2. Not as above 3
3. Orange tones muted and showing mostly as pale orange-yellow on margin but this changing to bister or fuscous when growth has ceased . . 5.*H. septentrionale*
3. Orange to orange-brown tones obvious 4
   4. Context of dried specimens showing dingy slate-bluish zones, pileus soon dull rusty ferruginous . . . . . 4. *H. ferrugipes*
   4. Pileus whitish on fresh growing surface, becoming orange; context never with slate-blue zones . . . . . .6. *H. aurantiacum*

4. *Hydnellum ferrugipes* Coker, Jour. Elisha Mitchell Sci. Soc. 34: 188. 1919. Fig. 14.

Calodon ferrugipes (Coker) Snell, Mycologia 37: 48. 1945.

Pileus: 5-15 cm broad, plane, disc slightly depressed, colliculose, surface dry and velvety; color "light ochraceous-buff" with the margin blue, buff area staining dingy yellow-brown when injured and finally blackish, turning brown then blackish in age from the disc outward. Context duplex; inner layer semi-woody, zoned with blue to pale buff bands; outer layer thin, buff and rather spongy; with a pungent farinaceous odor when cut and taste pungent-disagreeable.

Spines: Up to 6 mm long, crowded, sharp, deep vinaceous brown in age.

Stipe: 3-6 x 1-1.5 (2.5) cm, woody, fibrous, the core zoned as in the pileus and outer layer a soft coat of felted mycelium, orange tawny, slowly turning dark brown when handled.

Chemical reactions: In fresh material the blue zones of flesh and teeth turn green in KOH, no reaction to $FeSO_4$; when sections are placed in KOH the blue zones and teeth turn olivaceous green with some muddy brown pigment leaching out.

Spores and Hymenium: Spores in deposit wood-brown, 5.5-7 x 5.5-6.5 μ, semiglobose, tuberculate with 8 or 9 low processes. Basidia 6-7 x 20 μ, sterigmata fine up to 4 μ in length. A number of abnormalities were seen in the hymenium. (It appeared that some of the first basidia had been checked before normal sterigmata were formed and the ends became filled with a dense globule of granular material resembling a large spore, resulting in a capitate 'cystidium'.)

Tramal characters: There seemed to be three layers to the context, a rather thin upper interwoven spongiose layer zoned with fine dark bands, then a layer of parallel hyphae that tended to form dark bands and next a layer of very hard tissue often bluish. The parallel hyphae were in strands, and were 4-6 μ in width, tough, but easily teased apart. Clamps were occasional on the parallel hyphae. Hyphae are somewhat incrusted and areas that were blue had hyphae that were "Apparent-amyloid" with "apparent-amyloid" globules free in the context. Orange incrustations were seen in the tramal hyphae of the teeth but no clamps were seen there.

Habit, Habitat, and Distribution: Occurring in deciduous or mixed woods. Most frequently found in North Carolina. In Michigan one collection from Cassidy Lake Road near Ann Arbor, and one from the George Reserve, Livingston County.

Michigan material examined: Smith 64102 and 64190.

Discussion: *H. ferrugipes* has been confused with *H. aurantiacum* in North America. It is a distinct species as based on the type and original description, but by 1951 when Coker and Beers published their final description of *Hydnellum* species their concept of this one had changed. The original concept had been altered and the very blue-fleshed collections were identified as *H. cyaneotinctum* Peck. Coker also was confused about *H. aurantiacum,* for he identified a typical collection of *H. aurantiacum* from Bar Harbor, Maine as *H. ferrugipes* for Dr. W. H. Snell and this was passed on through identifications by Snell to Canadian mycologists. Thus records of *H. ferrugipes* in the northern part of the country prior to 1957 are questionable. Coker and Beers (1951) compared *H. ferrugipes* with *H. aurantiacum* but their description of *H. aurantiacum* is actually of *H. earlianum* Banker. *H. aurantiacum* and *H. caeruleum* (=*H. cyaneotinctum* Peck) were unknown to Coker in the fresh condition.

5. *Hydnellum septentrionale* K. Harrison, Canad. Jour. Bot. 42: 1224. 1964. Fig. 15

Pileus: 4-15 cm broad, convex, soon dividing into sections that develop and become processes and pileoli, often forming rosettes; margin elevated, thick, tomentose, spreading and thinner in age and then striate; surface deeply scrobiculate, sometimes radiately ridged, yellowish pallid to "pale orange-yellow" on actively growing parts, becoming "cinnamon-drab" to "fuscous" and finally "blackish-brown" or "bistre" at center; each process and pileolus may show a range of color so that the color pattern appears very complex. Context soft, becoming fibrous and hard in age, woody in the stipe, zonate from numerous dark lines, "clay-color" or near "pinkish-buff"; odor and taste varying from faint to strong and disagreeable.

Spines: Up to 5 mm long, decurrent, fine, close, sometimes fused, pale yellowish, becoming "cinnamon-drab," almost black in age, tips lighter with a tint of yellow.

Stipe: 3-5 x 0.6-2 cm, short, stout, subbulbous, tapering to a small root-like tip, "salmon buff" to "apricot buff" becoming "blackish brown," with salmon-colored mycelia in duff around base; context duplex: outer layer thin and spongy, felted; inner layer hard, sordid "clay-color."

Spores and Basidia: 4.5-5.5 x 3.5-4.5 μ, colored, oblong to subglobose, with low tubercles, appearing to be slightly amyloid in Melzer's reagent (but after many tests it was decided that the color was not intensified by the solution). Basidia 30 x 6-7 μ; sterigmata 3-4 μ long.

Tramal characters: Hyphae uniform throughout, 4-5 μ wide, flexuous, interwoven and the septa far apart and without clamps, 3-4 μ diameter in the radicating stipe, flexuous, closely interwoven and the outer walls coated with fine, faintly colored granules.

Chemical reactions: No reaction in KOH or Melzer's solutions.

Habit, Habitat, and Distribution: Gregarious, concrescent, frequently in rosettes, under fir and spruce, near the shore of the Straits of Mackinac.

Material examined: Smith 33082, 33121, 34000A, 36110, 37138, 38371, 38569, 39379, 41971, 42394, 60795.

Discussion: This is another of the American species in stirps *Aurantiacum.* It is not bright colored and is more solid and woody than most of the group. When old, it resembles *H. frondosum* K. Harrison, but when young the yellowish color distinguishes it. The spores are larger.

Collection Smith 34000A, from the Mackinaw City hardwoods, September 1949, consists of a large number of carpophores. They are stout, turbinate, and the spines are very close. On some of these there are concentric bands of poroid tissue with normal spines near the stipe and on the pileus margins.

6. *Hydnellum aurantiacum* (Batsch ex Fries) Karst., Medd. Soc. Fauna Fl. Fenn 5: 41. 1879.
Fig. 16.

Hydnum aurantiacum Fries, Syst. Myc. 1: 403. 1821.
Hydnum floriforme Schaeff., Fung. Bav. 4: 97. 1774, pro parte

Pileus: 6-18 cm broad, convex, plane or depressed, often colliculose, sometimes quite smooth and then breaking into processes with teeth forming large rosettes, often extremely rough with projections, surface uneven, tomentose, felted and becoming matted in age, sometimes zonate, margin "orange-ferruginous," center dark rusty brown to "bay"; margin whitish to tan in some northern collections. Context fibrous, tough, zonate, rusty orange in stipes and buff in pileus; odor and taste pungent, disagreeable.

Spines: 5-7 mm long, decurrent, close, coarse, dark brown with grayish buff tips. Pileus margin sterile or with tiny white undeveloped spines.

Stipe: 2-7 x 0.5-2 cm, base bulbous, single or several growing from a cushion of mycelium; context woody at center, orange-red, zonate; surface matted with orange to brownish tomentum, orange mycelium incorporates the duff in the bulbous base.

Chemical reactions: Further tests are needed on this and related species. The surface turns black in KOH and the flesh darkens to a dirty olive.

Spores and Hymenium: Spores 5.5-7.5 x 5-6 μ, appearing dark as though slightly amyloid, subglobose, roughly tuberculate. Basidia about 30 x 6 μ, clavate, 4-spored.

Tramal characters: The outer spongiose layer of rather closely interwoven hyphae $\pm$ 3 μ wide, branched, septate, clamps not seen; the harder inner layer with hyphae 3-3.5 μ wide, parallel, compact, tubular, septate, sparsely branched, no clamps observed. The hyphae in the spines are 2.5-3 μ wide, septate, and lacking clamps. Some granules present in the context of the pileus and spines but most were free of the hyphal walls.

Habit, Habitat, and Distribution: Solitary to gregarious or concrescent, under conifers in Europe and North America generally.

Material examined: Bartelli Oct. 3, 1965. Mains 6529. Imshaug Sept. 10, 1949. Harding 296. Smith Aug. 13, 1940, Aug. 1949, 42387, 42398, 72005, 72785.

Discussion: This species is one of the striking species in the genus and has been frequently renamed because of the extreme variability that it displays in different regions. Usually each region has rather distinct forms that are consistent within that area and are more or less distinct from those of other regions. We have limited our species to the group with large spores, slightly darkened in Melzer's reagent. The spores are wide (5-6 μ) so that the subglobose spores are easily recognized as large. However, even with this restriction a multiplicity of forms and variations are encountered. The colors range from dull brown to brilliant orange; the texture and spongy layer on the surface grades from soft and thick to firm and thin. The large spores separate this species from *H. earlianum* Banker and *H. conigenum* (Peck) Banker. The brighter colors readily separate it from *H. septentrionale* K. Harrison. Any specimens with slaty shades in the flesh should be compared with *H. ferrugipes*. One collection from Baraga County has spores up to 8.5 x 6.3 μ.

7. *Hydnellum earlianum* Banker, Mem. Torrey Bot. Club 12: 161. 1906
Fig. 17.

Hydnum earlianum (Banker) Sacc. et Trott., Syll Fung. 21: 271. 1912.

Pileus: 3-10 cm, in rosettes up to 15 cm with numerous overlapping pilei, single pileus depressed but margin lobed and sometimes faintly zoned, usually somewhat lighter when actively growing, surface smooth, occasionally irregular, tomentose or as though dusted with orange powder, bright color well retained in dried specimens, color becoming darker in center ranging from deep ferruginous to cinnamon-rufous. Context duplex, with a soft upper layer and a somewhat harder lower layer, soft and brittle, bright colored, usually a slightly lighter tint than the cap. Coker & Beers (1951) report a faint fragrant odor when dry.

Spines: Up to 3 mm long, decurrent, fine, close, color toward the margin a peculiar sulphur shade that persists for a long time, eventually becoming dark brownish shading from the stipe outward, tips lighter, sometimes yellowish.

Stipe: 2-5 x 1-2 cm, expanding into a bulbous base, compound or several starting from one cushion of mycelium, tapering upwards, expanded near spines; base 2-8 cm, globular, a mixture of orange-colored mycelium and duff; duplex, the outer covering smooth, concolorous or brighter than pileus, rusty brown in age.

Chemical reactions: KOH stains the bright colored tissue a very dull dark "olivaceous."

Spores and Hymenium: 4.5-5.5 x 4-4.5 (many 4.5 x 4) μ; oblong- to subglobose-tuberculate, tubercles rather short, dark under the microscope as though faintly amyloid. Basidia about 20 x 6 μ, clavate, 4-spored; a few reddish granules present in sections in the subhymenial region.

Tramal characters: Hyphae of the outer (spongiose) layer 3-3.5 μ wide, heavily incrusted with reddish brown granules; in the inner (harder) layer the

hyphae 3.5-4.2 μ wide, parallel, septate, heavily incrusted with granules and many granules free in the context of both layers. Hyphae in teeth about 3 μ in diameter, incrusted with reddish granules. Clamp connections absent.

Habit, Habitat, and Distribution: Gregarious becoming concrescent, in open oak woods, common in southern Michigan during wet seasons. It occurs widely scattered in the eastern United States and in Ontario.

Material examined: Kauffman 1069, 1072. Fisher Aug. 27, 1905. Mrs. Cohn Aug. 5, 1927. Mains 6528. Povah 342. Shaffer 2502. Thiers 3679. Smith 1591, 1723, 6851, 7055, 7184, 18458, 18731, 38377, 62599A, 62851, 63416, 63417, 64126, 64223, 64358, 64845, 72005, 72785.

Discussion: This species is outstanding because of the brightness of the orange color of the pileus and the sulphur yellow spines when they are actively growing. The Michigan collections show quite a range in color and toughness but until single basidiocarps have been watched throughout the growing season it will be unwise to attempt any further separation of minor taxa. This species typically occurs under oak whereas *H. aurantiacum* is usually associated with conifers.

8. *Hydnellum conigenum* (Peck) Banker, Mem. Torrey Bot. Club 12: 160. 1906. Fig. 18.

Hydnum conigenum Peck, Bull. Torrey Bot. Club 30: 97. 1903.

Pileus: 3-7 cm broad, depressed to deeply infundibuliform, complicate, lobed, flabelliform, concrescent forming rosettes 8 to 10 cm across; surface irregular, radially ridged, fibrillose, tomentose, striate, or ridged, faintly to strongly zoned more or less "pinkish cinnamon" to "cinnamon-buff," "apricot-buff" to "mahogany red" (one collection tinted "orange-cinnamon"), darker in age; margin wavy and lobed. Context thin, tough, pliant "pinkish cinnamon"; taste strongly farinaceous; odor none to farinaceous.

Spines: Up to 3 mm long, deeply decurrent, close, fine, concolorous with cap (or a brighter orange).

Stipe: 3-6 x 0.5-2.0 cm, simple or compound, bulbous at the base, more or less orange-brown, with a mass of felted tomentum at the base.

Chemical reactions: In fresh condition KOH turns flesh drab and in Melzer's reagent and $FeSO_4$ it becomes dull and water-soaked in appearance. Tramal tissue after drying turns dull olivaceous in KOH and remains orange in Melzer's.

Spores: 4-5.5 x 3.5-4.5 μ subglobose to oblong, angular, with young spores showing a prominent mucro, dark as though slightly amyloid.

Tramal characters: Hyphae heavily incrusted, $\pm$ 3 μ wide in the teeth and up to 6 μ in the pileus, frequently swollen at the septa, no clamps seen; numerous hyphae (laticifers?) seen in the hymenial layer with heavy concentrations of reddish granules; granules not darkening in Melzer's.

Habit, Habitat, and Distribution: Gregarious or concrescent in coniferous forests. Common in the Pacific Northwest. Collections seen from New Mexico to British Columbia; type locality Idaho; one collection from Isle Royale, Michigan.

Discussion: This is a very distinct species, especially bright colored at first and in age with a dark, very rough radially ridged surface. It is almost always concrescent and frequently complicate. It is in this condition that it incorporates cones into the basidiocarp and two of the eight collections examined contained cones embedded in the base of the compound stipe.

This species is separated from *H. aurantiacum* by its distinctly narrower spores; from *H. septentrionale* by its thin, brightly colored flesh; and from *H. earlianum* by the thinner non-duplex flesh.

H. conigenum, from the description, resembles the specimens in Europe that have been identified by Maas Geesteranus as *H. auratile* Britzelmeyer. However we are retaining the American name for several reasons. First the type of *H. auratile* has not been found and in our experience it is unwise to identify any species in the *Hydnellum aurantiacum* complex without specimens; second the western collections are much larger than the Euopean specimens identified as *H. auratile.* Also the original description called for "margine albidum" which does not apply to *H. conigenum* or the collections identified by Maas Geesteranus. The long-persistent orange shade of the margin is diagnostic. Many of the western collections are strongly zonate in age. The Michigan collection is young, only slightly zonate, and the surface is radially ridged, but otherwise it agrees well with *H. conigenum.*

Stirps *Spongiosipes*

9. *Hydnellum spongiosipes* (Peck) Pouz., Česká Mykol. 14:130. 1960
Fig. 19.

Hydnum spongiosipes Peck, Rep. N. Y. St. Mus. 50: 111. 1897.
Hydnellum velutinum (Fries) Karst. var. *spongiosipes* (Peck) Maas G., Fungus 27: 62. 1957.

Pileus: 2-10 cm broad, usually convex to irregularly plane, occasionally depressed, azonate or rarely with a concentric ridge of secondary growth on the margin, at times misshapen through fusing; surface finely tomentose, uneven or slightly colliculose, rarely substriate towards margin if margin thin, darkening when bruised when young and margin drying black where bruised; color cinnamon-brown, walnut to Vandyke-brown and with a grayish-brown bloom. Context duplex, upper layer thick, spongy; lower layer dark and rather thin, connecting with the hard core of the stipe, cinnamon-brown, compact layer in stipe darker; odor and taste mild.

Spines; Up to 6 mm long, decurrent, close, slender, dark to light brown with tips slightly lighter when young, darkening when bruised and injuries drying blackish.

Stipe: 3-10 x 0.5-2 cm, appearing short, narrowest next the spines, expanding quickly to a very broad bulbous base 4-5 cm wide, wider when several arise from a tomentose pad of mycelium; context duplex, central core hard, zonate, dark brown, surrounded by a thick felty layer of spongiose tissue.

Chemical reactions: Sections of dried material in KOH give a violet flash and then go black, and a dark olivaceous-brown color leaches into the mounting medium.

Spores and Hymenium: Spore deposit cocoa-brown; spores 5.5-7 x 5-6 μ, many 6.5 x 5.5 μ, walls thick, apiculus prominent, shape subglobose, moderately to coarsely tuberculate, (7 or 8 tubercles around circumference), tubercles stud-like to angular with truncated ends. Basidia 6-7 x 20-25 μ, sterigmata $\pm$ 4 μ long.

Tramal characters: Tramal hyphae of teeth 3-4 μ wide, tubular, parallel, septate but not clamped. In Melzer's reagent the hyphae 3.5-6.0 μ, thin-walled, end cells at surfaces with russet colored contents; hyphae of interwoven spongiose layer changing abruptly to the radial tissue of the compact lower layer, 4.5-5.5 μ wide, small pockets of amorphous russet colored material occurring in the layer, occasional laticiferous hyphae present and filled with russet contents but these could not be traced to the pockets. The hard radial tissue supports the teeth and is continuous with the hard tissue in the stipe.

Habit, Habitat, and Distribution: Solitary, gregarious, or connate; on rather dry hillsides as well as on low ground in deciduous woods, usually oaks predominate. Common in the deciduous woods of southern Michigan where oaks are found. We have no collections from the Upper Peninsula. Widely reported from Iowa east to the Atlantic seaboard. Reports from other areas under pines should be checked against *H. pineticola.*

Material examined: Mains July 7, 1915, Aug 7, 1915, 6531, 8153. Shaffer 2750, 2788, 2818. Kauffman Aug 1, 1915; Rea 971. Potter 3805, 11135, 11136, 12764. Smith 32308, 1724, 6784, 6891, 6904, 7070, 6138, 7294, 18529, 18743, 18768, 20871, 62815, 62837, 62852, 63078, 63889, 64118, 64163, 64198, 64250, 64360, 64806, 73288.

Discussion: One collection was found where the margin of the fungus encountered the margin of a narrow leaf of a deciduous shrub. The point of contact appeared to be the dividing line between the spongiose tissue and the hard layer bearing the teeth. The spine-bearing layer produced one or two teeth below the leaf margin before growth ceased, but the spongiose tissue continued growing, covering the leaf with a layer of tissue 5-6 mm thick. No layer of hard spine-bearing tissue developed on the lower surface until after the spongiose tissue had completely covered the leaf surface and extended over the far side. Then spines were formed and the darker firm tissue was in evidence again. It is concluded that the spongiose tissue is primary and produces the compact layer with spines under suitable stimulus.

The name *H. spongiosipes* is reserved for the species under oak originally described by Peck. The presence of a rather similar fungus, *H. pineticola,* from under *Pinus* spp. was not considered until reported by Harrison (1964) although Maas Geesteranus has pointed out that Coker & Beers' description of the same fungus as *H. velutinum = H. spongiosipes* varied somewhat from the usual concept of that species.

Maas Geesteranus (1957) placed *H. spongiosipes* Peck as a variety of *H. velutinum* when making his interpretation of the European forms. This disposition was followed by Harrison (1961) for the species from Nova Scotia now

considered *H. pineticola. H. spongiosipes* has not been found in Nova Scotia so now after a study of both species as they occur in Michigan it seems best to treat all these variations with the violet to black to olive-green KOH reaction under their original names. The finding of the species *H. cumulatum* in Nova Scotia in 1962 and by A. H. Smith in Michigan stresses the point that it may take many years of careful collecting to find the hydnums in even well-collected regions. It is no solution to the problem to consider the American species as a variety of *H. velutinum.* The Friesian description varies considerably from the American species under oak and there is no certainty that careful collecting in the type locality may not turn up a form that will fit the Friesian description. Until lectotypes are established from the type region that conform to the original description, it will not be possible to have stability in this erratic-fruiting group of fungi with such long-lived basidiocarps.

10. *Hydnellum pineticola* K. Harrison, Canad. Jour. Bot. 42: 1226. 1964. Fig. 20.

Hydnellum velutinum var. *spongiosipes* (Pk.) Maas G., in Harrison, Stip. Hyd. N. S. 44 and Pl. 3, fig. 10. 1961.

Pileus: 3-14 cm broad, convex, plane to slightly or irregularly depressed, whitish pubescent becoming matted, surface roughened; "pale vinaceous cinnamon," "vinaceous brown," finally "russet" to "Mars brown," occasionally with pink drops in humid weather; when handled staining "vinaceous-cinnamon" and finally "blackish-brown"; margin thick becoming thinner in age, pallid to "vinaceous-fawn." (This is also the color of secondary growth which may cover the surface or occur only as a broad band around the margin.) Context dark cinnamon, duplex, moist, tough, zonate, lower layer firm, with bands of crystals in zones, upper thick and spongy and also showing zonations (daily growth pattern); odor faintly fragrant to slightly acid; tase slowly disagreeable.

Spines: Up to 9 mm long, decurrent, fine, close, "pinkish-cinnamon" becoming "Rood's-brown" or darker (vinaceous brown), paler toward the margin.

Stipe: 2-4 (8) cm long, 1-2 (3) cm thick, solid, duplex, bulbous, zonate, concolorous with pileus context, surface layer felty from a layer of soft tissue, spongiose, inner layer hard, showing numerous crystals, base often radicating.

Chemical reactions: In KOH instantly black, in $FeSO_4$ olive-black on the dark bands. KOH on the dried flesh flashes violet, then black and quickly leaches leaving the tissue dull olivaceous.

Spores and Hymenium: Spores 4-5 x 4.5-6 μ, angular, oblong to subglobose, tuberculate, mucro inconspicuous, tubercles usually short. Basidia 5-6 x 20-25 μ, sterigmata 2-3 μ long.

Tramal characters: Hyphae of the teeth 2.5-6 μ flexuous, parallel, sparsely branched from close to the septa. Hyphae of the pileus trama parallel and flexuous in the firm part, loosely interwoven in the spongiose layer; compactly and complexly interwoven at the base of the teeth, 4-6 μ wide. Numerous oleiferous hyphae 7 μ wide with colored cell contents occur in the epicutis of the pileus; also frequent dark-colored spots and pockets of crystalline material which dissolve in KOH occur in the context.

Habit, Habitat, and Distribution: Gregarious, concrescent, usually under *Pinus* spp. on sandy plains, occasionally in mixed conifers. Northern Michigan and the Annapolis Valley of Nova Scotia.

Material examined: Imshaug 4682; Smith 34036, 38342, 38423, 38495, 38579, 42634, 42635, 42640, 50121, 50135, 50264, 58017, 61257, 63420, 64025, 67627, 72006, 72316.

Discussion: This species occurs in great numbers in stands of *Pinus resinosa* in Nova Scotia and under *Pinus banksiana* in northern Michigan. It grows from deep in the pine straw as a whitish column that starts to expand into a pileus as soon as it reaches the surface of the duff and in humid weather may exude red drops of liquid. This is a slow-growing species and if growth is checked by a change of weather, the manner in which it starts again will affect the shape of the pileus. If growth recurs over the whole surface, the resulting fruit body will be thick and turbinate or if only in a narrow band around the margin, it will be thinner and spreading. *Hydnellum spongiosipes* (Pk.) Pouz. has not been found in Nova Scotia, but is common in Michigan and, when the two species were compared, with adequate field notes, points of difference were found.

The spores are the most useful means of separating this species from *H. spongiosipes* (Pk.) Pouz. They average somewhat smaller (are mostly around 5.5 x 4.5 μ), more angular, and with shorter processes. *H. spongiosipes* has spores with a large mucro which are mostly around 6.5 x 5.5 μ with processes that may reach 2 μ in height. *H. pineticola* is very subject to discoloring from bruising and when growing actively cannot be touched without becoming discolored. The contents of the hyphae of the pileus are noticeably dark. Coker and Beers' (1951) description of *Hydnellum velutinum* and the illustration of the spores (Pl. 60, Fig. 8) are good for *H. pineticola.*

The latter differs from *H. spongiosipes* in that it is whitish at first and in Michigan occurs most abundantly under pines. In the herbarium *H. pineticola* has a "pinkish buff" to "vinaceous cinnamon" pileus, the spongiose tissue is "russet" to "Verona brown" and the flesh of the stipe is "Mars brown," while *H. spongiosipes* is "ochraceous tawny" to cinnamon" and the hard layer is "bister," "warm sepia," and "burnt umber." These differences will not separate old or weathered material.

Stirpes *Peckii* and *Scrobiculatum*–Key to Species

1. Spores with fine tubercles (appearing echinulate under ordinary magnifications) . . . . . 12. *H. cumulatum*
1. Spores with coarse tubercles 2
   2. Fresh context with a strong peppery to disagreeable after-taste in the throat . . . . . 11. *H. peckii*
   2. Taste not distinctive or merely slightly farinaceous to fungoid 3
3. Pileus regular, thin and distinctly zonate, usually the disc smooth to only slightly scrobiculate . . . . . 13. *H. scrobiculatum* var. *zonatum*
3. Pileus thicker than in above choice and typically scrobiculate and often complante in addition . . . . . 13. *H. scrobiculatum* var. *scrobiculatum*

Stirps *Peckii*

11. *Hydnellum peckii* Banker, Mycologia 5: 203. 1913.
Fig. 21.

Calodon peckii (Banker) Snell and Dick, *in* Snell *et al.*, Lloydia 19: 163. 1956.
Hydnellum diabolus forma *reticulatum* Coker & Beers, Stip. Hyd. East. U. S. 72. 1951.

Pileus: 3-14 cm broad, plane to depressed, margin slightly elevated; surface smooth, then uneven in center, with numerous scrupose projections, cottony fibrillose toward margin, becoming matted, glabrous in age, white at first, soon tinged pinkish, becoming buff-pink, in age "dull purplish-black" in the center and shading to a vinaceous margin, frequently exuding drops of reddish juice. Context coriaceous, zonate "pecan-brown" or darker, often exuding red juice when squeezed; odor none or slightly disagreeable, to pungent when squeezed, taste farinaceous but with a peppery after-taste in the throat, remaining peppery in dried material; margin and teeth stain reddish brown on handling.

Spines: 2-6 mm long, crowded, decurrent, "onion skin-pink" becoming "Pecan-brown" or dark umber at maturity.

Stipe: 2-7 cm long, 1.3 cm thick, surface irregular and rough expanding to a bulbous base of mycelium and duff, concolorous with pileus; context solid, dark "vinaceous-brown," drying with numerous granular inclusions.

Chemical reactions: The dull purplish black areas on the surface are dark in water under microscope and are "apparent-amyloid" in Melzer's reagent. The "apparent-amyloid" reaction has never been observed in *H. diabolus.* The same tissue turns blue-green in KOH and the inclusions dissolve in the solution. The reaction is usually faint and best observed under the stereoscopic microscope. The mycelium and granules are not changed when the hyphae are flooded with alcohol and resoaked in water.

Spores and Hymenium: Spores 4.5-5.5 x 3.5-4.5 μ, "army-brown" in mass, subglobose, tuberculate, tubercles rather low and some truncated.

Tramal characters: Hyphae loosely interwoven at the surface, with numerous yellowish laticiferous hyphae 7-8 μ in diameter, included in the layer; context zonate, parallel, clamp connections present regularly on the hyphae, with numerous amorphous inclusions in tissues of the stipe, these less frequent in pileus.

Habit, Habitat, and Distribution: Solitary, gregarious or subcespitose under conifers.

Discussion: This is one of the common species throughout the Pacific Northwest but has been a poorly understood species in the east. A few collections have been made in Nova Scotia but it was not properly understood until western collections were studied. Coker found it in North Carolina but did not recognize it and named it *H. diabolus* forma *reticulatum.* In the field *H. peckii* has a slightly disagreeable odor and is a squat, stout plant but the surface is very

uneven with numerous projections. The covering is cottony fibrillose and this mats down and takes on a very dark appearance. *H. diabolus* Banker, which is closely related, has a strong pleasant odor of bee balm *(Monarda didyma)* and the surface appears hirsute (unevenly strigose under the lens) and rarely matted. The differences in the surfaces of the two are recognizable in the herbarium.

The descriptions of this species and *H. diabolus* read very much like those of *H. ferrugineum* of Europe, and herbaria in North America contain many collections of these two under the latter name because of the presence of the red juice. However, the acrid taste persists in the dried material, and both *H. peckii* and *H. diabolus* can be recognized on this character. *H. diabolus* has now been recognized in Europe.

Stirps *Scrobiculatum*

12. *Hydnellum cumulatum* K. Harrison, Canad. Jour. Bot. 42: 1225. 1964. Fig. 22.

Pileus: 3-9 cm broad individually, connate, often concrescent, plane, convex, or concave, imbricate, rarely with concentric ridges near margin, spongiose to tomentose, "vinaceous-buff" to avellaneous", becoming "Hessian-brown" or "burnt-umber" or darker – almost black when wet; margin thin, elevated, with a zone-like growth band, "vinaceous-buff" to "avellaneous" to "brick-red"; context fibrous, firm, "brick-red" to ""Hessian-brown"; odor slightly aromatic, taste mild.

Spines: Fine, short, close, "liver-brown," becoming darker, not changing color when bruised (but rather mature when collected).

Stipe: 2-4 cm long, 0.5-1 cm thick, equal to subclavate, very little surface showing, concolorous with pileus to darker; context hard, fibrous, "brick-red" to almost black: a small amount of spongiose tissue present around the base.

Chemical reactions: No reaction in Melzer's solution but the KOH reaction was typical of stirps *Velutinum.*

Spores and Hymenium: Spores 4-5.5 x 4-5 μ, colored, subglobose, thin-walled, finely tuberculate (almost appearing echinulate) with prominent mucro. Basidia 5-7 x 20 μ, sterigmata up to 4 μ, fine.

Tramal characters: Hyphae in the spines 2.5-3 μ, parallel and flexuous; spongious tissue of interwoven hyphae at the surface, mostly 3-5 μ.

Habit, Habitat, and Distribution: Solitary to gregarious in connate masses, appearing sessile in the duff. On hillsides in mixed stands of mature *Pinus resinosa* and *Tsuga canadensis,* found on the edges of small hollows and in depressions around exposed roots, in unused rodent burrows and partly hidden by duff. Previously known only from Kings and Annapolis Counties, Nova Scotia, Canada.

Material examined: Smith 72082, 72317, 72479, from Luce County, Upper Peninsula.

Discussion: This species bears a remarkable outward resemblance to mature carpophores of *H. diabolus* Banker and this was supported by the slight aromatic odor. However, there was no trace of an acrid taste. The dried plants

are near snuff brown in color. The spores have a typical ornamentation that enables this species to be separated from *H. diabolus* in the herbarium. It bears little resemblance in outline to other species in the velutinum-scrobiculatum group. Apparently it fruits only at long intervals. The area where it was first found in the ravine on the Research Station, Kentville, Nova Scotia, has been a favorite collecting area for 35 years, and the species was first found in 1962. It was also found the same season in quantity in a similar habitat in another county. The heaped up appearance of the connate masses of pilei gives this fungus a characteristic appearance.

13. *Hydnellum scrobiculatum* (Secr. ex Fries) Karst., Medd. Soc. Fauna Fl. Fenn. 5: 41. 1879. var. *scrobiculatum,*
Fig. 23.

Hydnum cyathiforme a. Bull. ex Fries, Syst. Myc. 1: 405. 1821; non *H. cyathiforme* Schaeff. 1774.
Hydnum concrescens Pers., Mycol. Europ. 2: 164. 1825.
Hydnum scrobiculatum Secr. ex Fries, Mycogr. Suisse 2: 522. 1833.

Pileus: 2-7 (15) cm broad, singly to gregarious and concrescent in masses, convex, to shallowly infundibuliform or broadly depressed; margin thick, sometimes thin, elevated; surface finely to coarsely scrobiculate especially in the center or occasionally colliculose, rough, irregular or striately ridged towards margin, evenly coarsely velvety tomentose on smoother parts, dull onion skin-pink, becoming Rood's-brown or dark ferruginous, occasionally seen with reddish brown droplets of juice; margin zonate sometimes with alternating bands pecan-brown to buff-pink, staining bone-brown to blackish when injured. Context zonate, tough, fibrous to near woody, cinnamon-rufous to light brown, typically dry; odor and taste mild, slightly pungent to farinaceous disagreeable.

Spines: 1-2 (3.5) mm long, decurrent, very fine, close chestnut-brown to chocolate.

Stipe: 1-3.5 cm long, 1-4 cm thick, extremely variable from fusing, arising from a spongy tomentum, narrowing upward then expanding into pileus, concolorous; context tough, fibrous, woody in base.

Chemical reactions: When fresh: KOH dark olive, $FeSO_4$ olive black, Melzer's negative; when dried: KOH giving a violet flash then black and a dark olive color leaches out.

Spores and Hymenium: Deposit pale vinaceous brown; spores 5.5-6.5 x 4.5-5.5 μ, subglobose to slightly angular, many tubercles stud-like, blunt, 10 to 12 showing on circumference. Basidia 5.5-6.5 x 15-20 μ, clavate with broad ends. Hymenium up to 30 μ thick, no clamps seen.

Tramal characters: Spongiose layer very thin but the hyphae are 4.2-5.3 μ wide — mostly tubular but a few irregulary swollen, septate, thin-walled, no clamps seen. Some hyphal ends are filled with dark contents and dark debris was present amongst the strands. The harder inner layer of hyphae 3.8-4.5 μ wide, tubular, septate, no clamps seen. Two types of incrusting granules seen: the usual type was dark reddish brown and rarely pockets of granules were present

amongst the hyphae. Laticiferous hyphae with similarly colored contents were also present. The second type is present only on short segments of the hyphae. The hyphae are dark brown and this gives the impression that they are segments that would correspond to the "apparent-amyloid" hyphae in some other species of *Hydnellum.* The intense dark olive reaction in KOH in this species prevents any observations on whether these same tissues give the blue-green reaction that is usually associated with these dark granules in the other species. Hyphae of the spines are undulating, 2.5-4 μ wide, thin-walled, septate, and no clamps were seen.

Habit, Habitat, and Distribution: Solitary, gregarious, or concrescent, in deciduous and conifer woods throughout the state. We have collections from 9 counties. It is one of our most common hydnellums. It is widely reported in North America from the Atlantic to the Pacific Ocean in forested areas and from Canada to Alabama.

Material examined: Mains 4532, 6590. Harding 326. Shaffer Aug. 6, 1960. Thiers 1096. Smith 1725, 7081, 18500, 18501, 18531, 18532, 32884, 33121, 35839, 50263, 50583, 57835, 62853, 64028, 64189, 64229, 64329, 64835, 72464, 75034, 75120.

Discussion: The species described here forms part of a complex group that includes *"H. zonatum"* and in this paper is being restricted to collections with spore ornamentation in the form of tubercles. The two varieties are quite uniform in their appearance and in most cases the var. *zonatum* can be distinguished by being thinner, rarely as scrobiculate and typically more conspicuously zonate. When collections of this complex from all over North America are brought together and studied it is fairly easy to pick out eight or ten distinct forms associated with the different regions. It is hoped that eventually it will be possible to arrive at a classification that can be used to differentiate these into recognizable varieties that will be useful for studying the variation within the group or to aid in understanding their ecological reactions.

Fries originally described *H. scrobiculatum* and *H. zonatum* as distinct but they have been the subject of confusion ever since. Banker treated the North American complex under a number of names and attempted to associate them with European names. He also added the new species *H. parvum* Banker, a small southern form growing in pine straw. Miller and Boyle (1943) were doubtful if two species could be distinguished. Coker and Beers (1951) treated the eastern North American forms under five species names. Harrison (1961) working in Nova Scotia considered *H. zonatum* a variety of *H. scrobiculatum* while Lundell in 1959 issued *zonatum* as a subspecies of *Hydnum scrobiculatum.* Maas Geesteranus in Europe considers them all varieties of *H. velutinum,* which is another species described by Fries which has to be interpreted from the original description and tradition as no type exists. The name has been applied to a number of species none of which fit the original description accurately.

Hydnellum scrobiculatum (Secr. ex Fries) Karst. var *zonatum* (Batsch ex Fries) K. Harrison, Stipp. Hyd. N. S. 43. 1961.
Figs. 24 & 25.

Hydnum zonatum Batsch, Elenchus, Contin. sec. 109, pl. 40, fig. 224. 1789; non *H. zonatum* Batsch, Elenchus 111. 1783.
Hydnum cyathiforme b. Fries, Syst. Myc. I: 405. 1821; non *H. cyathiforme* Schaeff. 1774
Hydnum zonatum Batsch ex Fries, Epicr. Syst. Myc. 509. 1836-38.
Hydnellum zonatum (Fries) Karst., Medd. Soc. Fauna Fl. Fenn. 5: 41. 1879.
Hydnellum velutinum var. *zonatum* (Fries) Maas G., Fungus 27: 64. 1957.

Pileus: 3-6 cm broad, convex, infundibuliform, margin thin, rarely "thick" unless small, zonate, usually elevated, center often slightly scrobiculate, surface rough, finely fibrillose on margin, bright to dark rusty cinnamon; margin fibrillose, thin, sterile, rarely "thick" unless basidiocarp is young, usually elevated, near vinaceous pink, staining vinaceous cinnamon when bruised. Context 2.5-3.5 mm thick, zonate, soft-fibrous to tough, sometimes soft, light brown to vinaceous russet; taste mild, odor slight. One collection had a rancid taste.

Spines: Up to 3 mm long, decurrent, very close and slender, dark vinaceous cinnamon.

Stipe: Up to 3 cm long, 0.5-1 (2.5) cm thick, simple or compound, arising from a tomentose pad of mycelium; context zonate and hard.

Chemical reactions: When fresh: KOH instantly fuscous to olive black; $FeSO_4$ dark olive fuscous next to teeth; dried: KOH gives a violet flash and the black dissolves in the liquid as a dark olive pigment.

Spores and Hymenium: Spores 4.5-5.5 x 4-4.5 μ, angular, tuberculate, in Melzer's reagent as seen in groups showing a yellowish-red tint. Basidia 20 x 5.3 μ, clavate, 4-spored.

Tramal characters: Only a few strands of spongiose tissue present on surface of pileus. Hyphae 3-4 μ wide, thin-walled, frequently septate, not clamped, many ends filled with reddish brown contents and resembling laticifers. The ends often associated with the band of crystalline material marking the hyphal zones; some hyphae incrusted but granules usually intercellular, occasional visible pockets of reddish brown material present, no evidence of apparent-amyloid hyphae seen; both spongiose and context hyphae radially oriented; inner layer of hyphae 3.5-4 μ wide, thin-walled and some slightly incrusted, tubular, septa numerous. Hyphae of spines 2.5-3 μ, parallel except in the base where they appear interwoven.

Habit, Habitat, and Distribution: Solitary, gregarious, or in concrescent masses in conifer and deciduous woods. It is common throughout the state as well as in forested areas of North America generally. It was described, of course, from Europe.

Material examined: Kauffman Sept. 24, 1904, Oct. 1907. Mains July 30, 1915, Aug. 1, 1915, Aug. 6, 1915, 1076, 1071. Lowe 124, 172. Harding 250, 293, 301. Smith 32-266, 1739, 6876, 6950, 6955, 7046, 7141, 7155, 7180, 7285, 7288, 18502, 18530, 18543, 18729, 18751, 18752, 18769, 20730, 20781, 33085, 34000, 37139, 37283, 38111, 38487, 38498, 62611, 64059, 64113, 64228, 64356, 64631, 67500, 67793.

Discussion: The spore differences between this and var. *scrobiculatum* are slight. In the field the thinner, more zonate, smoother pilei are the major distinction. For additional comment see var. *scrobiculatum.*

Stirps *Geogenium*

14. *Hydnellum geogenium* (Fries)Banker, Mycologia 5: 204. 1913.

Hydnum geogenium Fries, Sv. Vet.-akad. Forh., 131. 1852.
Calodon geogenius (Fries) Karst., Medd. Soc. Fauna Fl. Fenn 6: 16. 1881.

Pileus: Concrescent clumps up to 25 cm across with individual pilei up to 6.5 cm broad, variable in shape, shelving, substipitate, thin, pliant, subzonate, surface fibrous with radiating ridges, center scrobiculate; margin variously lobed, undulating or irregular, color "deep colonial-buff" to "olive-yellow" when rubbed buffy-olive. Context thin, pliant, olive beneath the honey-yellow surface layer; no odor or taste.

Spines: 3-6 mm long, decurrent, close, fine, "olive-ocher" (olive-yellow) becoming dark "vinaceous-brown" in age with "olive-ocher" tips.

Stipe: None or very short. The soil around the base filled with numerous strands of greenish-yellow mycelium.

Chemical reactions: In dried material a dark olivaceous pigment dissolved out into the KOH solution and areas of green hyphae were evident in the tramal tissue near the surface and some of the zones.

Spores and Hymenium: Spores dark "vinaceous-brown" in mass, 3-4.5 x 3-4 μ, angular to subglobose, tuberculate, tubercles rather low, prominent apiculus. Basidia 10-40 x 4-5 μ, clavate, 4-spored.

Tramal characters: In KOH, the surface hyphae 2.5-5.5 μ wide, thin-walled, interwoven, with branches and usually near a branch a septum with a large medallion clamp; the loop of the clamp nearly as broad as the hypha. There is also a system of hyphae with somewhat darker contents (laticifers?) and the dark contents often end abruptly at a clamped septum. In Melzer's solution the laticiferous system shows up plainly and many of the surface hyphae contain black granules. The main context of the pileus consists of hyphae 3-4 μ wide, tubular parallel, septate and with large clamps at some of the septa. The laticiferous hyphae are $\pm$ 5.5 μ wide. The hyphae in the spines are 2.5-3.8 μ wide, parallel, thin-walled, and with clamps.

Habit, Habitat, and Distribution: Solitary, gregarious, concrescent under conifers. The only collection known from the west is Smith 52917, San Juan, Colorado. Common in Nova Scotia. Reported along Atlantic seaboard from North Carolina to Quebec. Probably will be found in the Upper Peninsula.

Discussion: This is a common species in the northern coniferous forests in the eastern part of the continent. It occurs on slopes and along stream banks in large concrescent masses. It is much rarer south but has been found in Georgia. There it occurs as individual stipitate fruit bodies. When growing luxuriantly it starts as a group of bright yellow columns on a cushion of yellowish mycelium. It grows so compact and close to the ground that it often appears to be sessile,

and it may grow out on the underside of exposed roots and lumps of soil. Its bright yellow margin and mycelium, along with the dull olivaceous pileus are characters that make this species conspicuous and easy to recognize.

Stirps *Mirabile*

15. *Hydnellum mirable* (Fries) Karst., Medd. Soc. Fauna Fl. Fenn. 5: 41. 1879.

Hydnum mirabile Fries, Monogr. Hymen. II: 349. 1863
Calodon mirabilis (Fries) Karst., Medd. Soc. Fauna Fl. Fenn. 6: 16. 1881.

Pileus: 4-15 cm broad, broadly convex or flat, surface becoming irregular and the obtuse margin lobed, densely tomentose to short strigose, plush-like near margin but tomentum aggregated into coarse upright projections over most of the surface; color very sordid yellowish buff becoming dirty dark yellowish-brown. Context thick, coriaceous, woody, softer toward surface, zoned with dark brown lines, pallid to dull buff otherwise, with a copious dull umber juice, in base of stipe "pale grayish brown" with lighter areas near surface; odor faint of raw cucumber or subfarinaceous, taste faint, subfarinaceous but finally slowly acrid.

Spines: 2-5 mm long, decurrent, distant, crowded, in age frequently flattened, often with several tips, pallid wood-brown to clay-color.

Stipe: 2-3 x 2-4 cm, enlarged upward, hard and firm but breaks cleanly and exudes a dingy watery juice, scabrous from undeveloped teeth, yellowish brown, tomentose in patches; context corky, dingy (pale grayish brown).

Chemical reactions: No reactions obtained with KOH or Melzer's reagent.

Spores: Spores 4.5-6.5 x 4-5.5 μ, colored, subglobose, coarsely tuberculate, tubercles usually short, 8 or 9 showing on circumference.

Tramal characters: Context drying very hard and woody and the teeth hard and brittle, not reviving readily in Melzer's solution.

Habit, Habitat, and Distribution: Gregarious, subcespitose, in mixed and coniferous woods. Recorded under pine and hemlock from Idaho, Oregon, and Washington. Rare in eastern United States, Canada, and Europe. One collection from Tennessee. Its occurrence in the coniferous forests of Nova Scotia and the Pacific Northwest leads to its inclusion here as a species that will probably be found in the Upper Peninsula.

Discussion: This species is rarely collected, possibly because it is so attractive to slugs. It starts as straw-colored cushions of mycelium that exude coffee colored drops of juice and this characteristic is apparent when the flesh and particularly the stems are broken. The juice dries and darkens the mycelium so that old specimens become very sordid and dark in appearance. One or more fruit-bodies may arise from one cushion and then they are very irregular in shape. There is a strong tendency for regrowth following injury and when this happens the new mycelium is white at first. The teeth at first are distant and terete, but in age they are often fused in plates with two to several tips. The decurrent teeth next to the stipe frequently fuse with it and become partially

buried. This species is very low and squat and when seen actively growing resembles *Polyporus schweinitzii.* There is a layer of spongy tissue near the surface which dries hard especially in young basidiocarps.

ACKNOWLEDGMENTS

The preparation of this paper was possible because of the efforts of many amateur and professional mycologists who gathered hydums over the years and deposited them in the University of Michigan Herbarium. My thanks are extended to these many persons past and present. It is with gratitude that I acknowledge the importance of the contributions made to this paper by Prof. A. H. Smith, Director of the University of Michigan Herbarium. He not only has found the majority of the collections recorded here but generously granted permission to make full use of the numerous field notes and photographs accompanying the specimens. The microscopic studies were made and the paper prepared during the tenure of NSF grant GB 4853 to the University of Michigan and the financial support essential for its completion is gratefully acknowledged.

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Fig. 1. *Phellodon niger* var. *alboniger* x1 Smith

Fig. 2. *Phellodon niger* var. *alboniger* x1 Smith

Fig. 3. *Phellodon tomentosus* x1 Smith 63984

Fig. 4. *Phellodon tomentosus* x1 Smith 70681

Fig. 5. *Phellodon confluens* ×1 Smith 64249

Fig. 6. *Bankera fuligineo-alba* ×1 Smith 67761

Fig. 7. *Bankera carnosa* ×1 Smith 72165

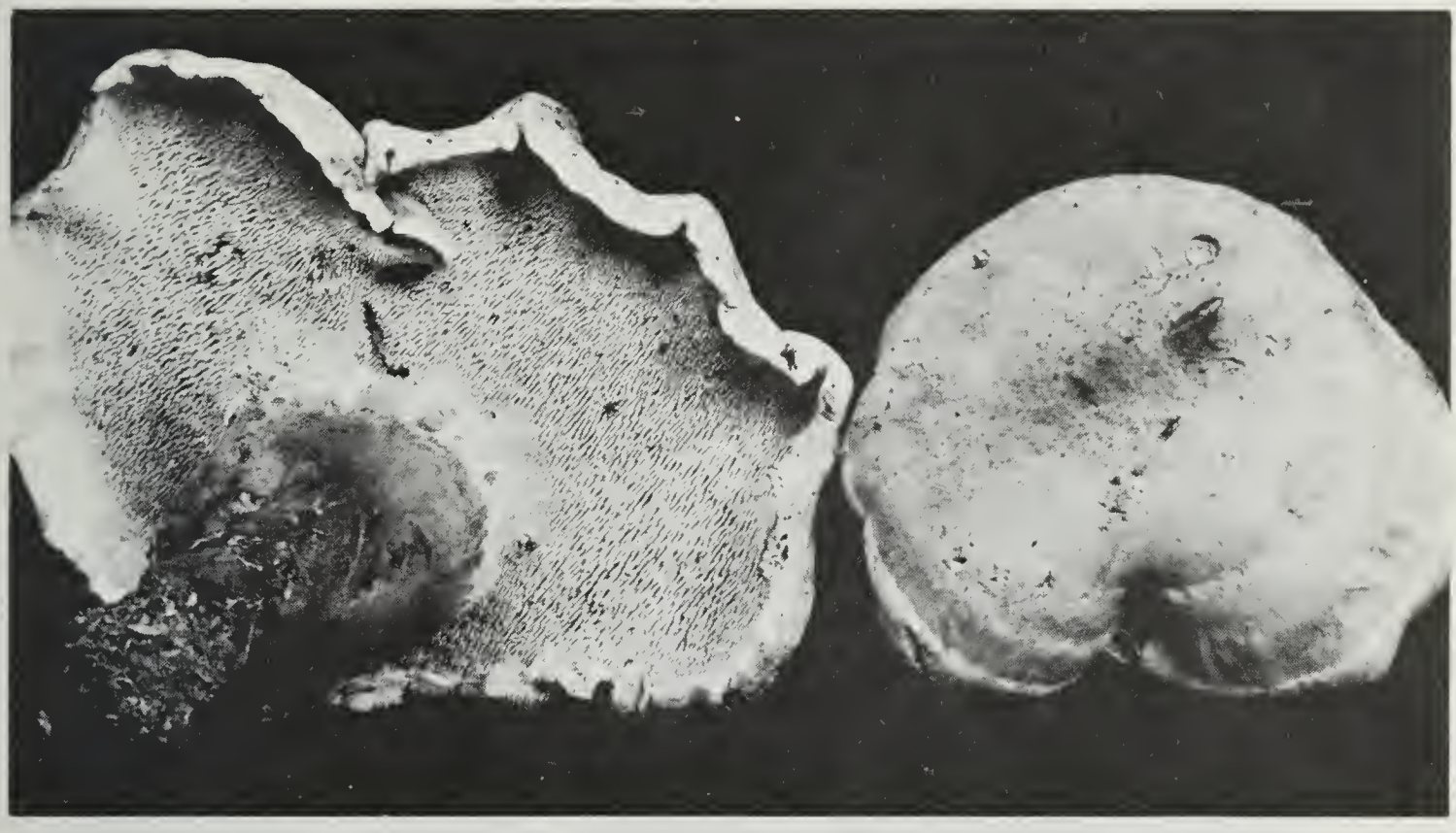

Fig. 8. *Bankera carnosa* x1 Smith 75033

Fig. 10. *Hydnellum humidum* ×1 Smith 64248

Fig. 11. *Hydnellum humidum* ×1 Smith 64248

Fig. 12. *Hydnellum humidum* ×1 Smith 64404

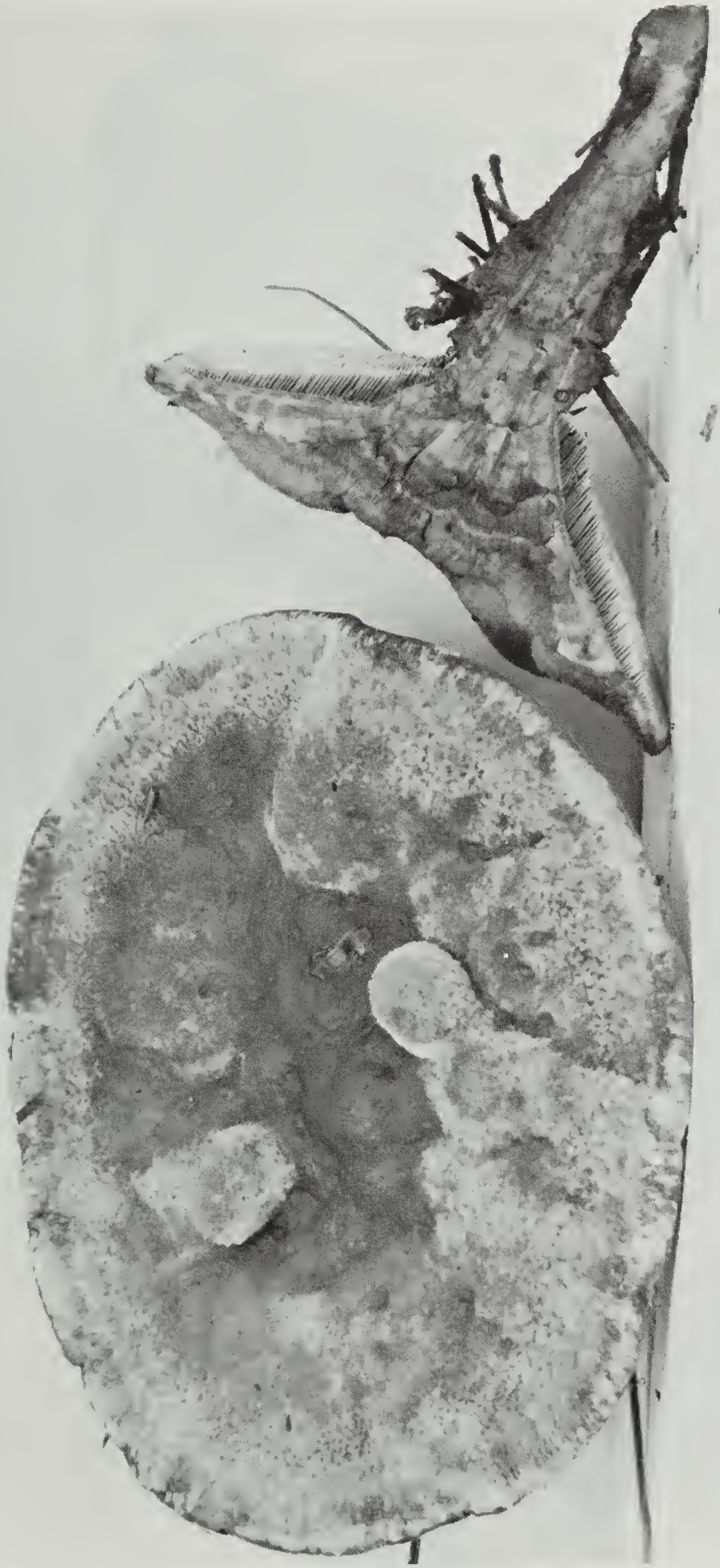

Fig. 13. *Hydnellum caeruleum* ×1 Smith 73311

Fig. 14. *Hydnellum ferrugipes* ×1 Smith 61402

Fig. 15. *Hydnellum septentrionale* ×1 Smith 33082

Fig. 16. *Hydnellum aurantiacum* ×1 Smith 66445

Fig. 17. *Hydnellum earlianum* ×1 Smith 62851

Fig. 18. *Hydnellum conigenum* ×1 Harrison 6226

Fig. 19. *Hydnellum spongiosipes* ×1 Smith 73288

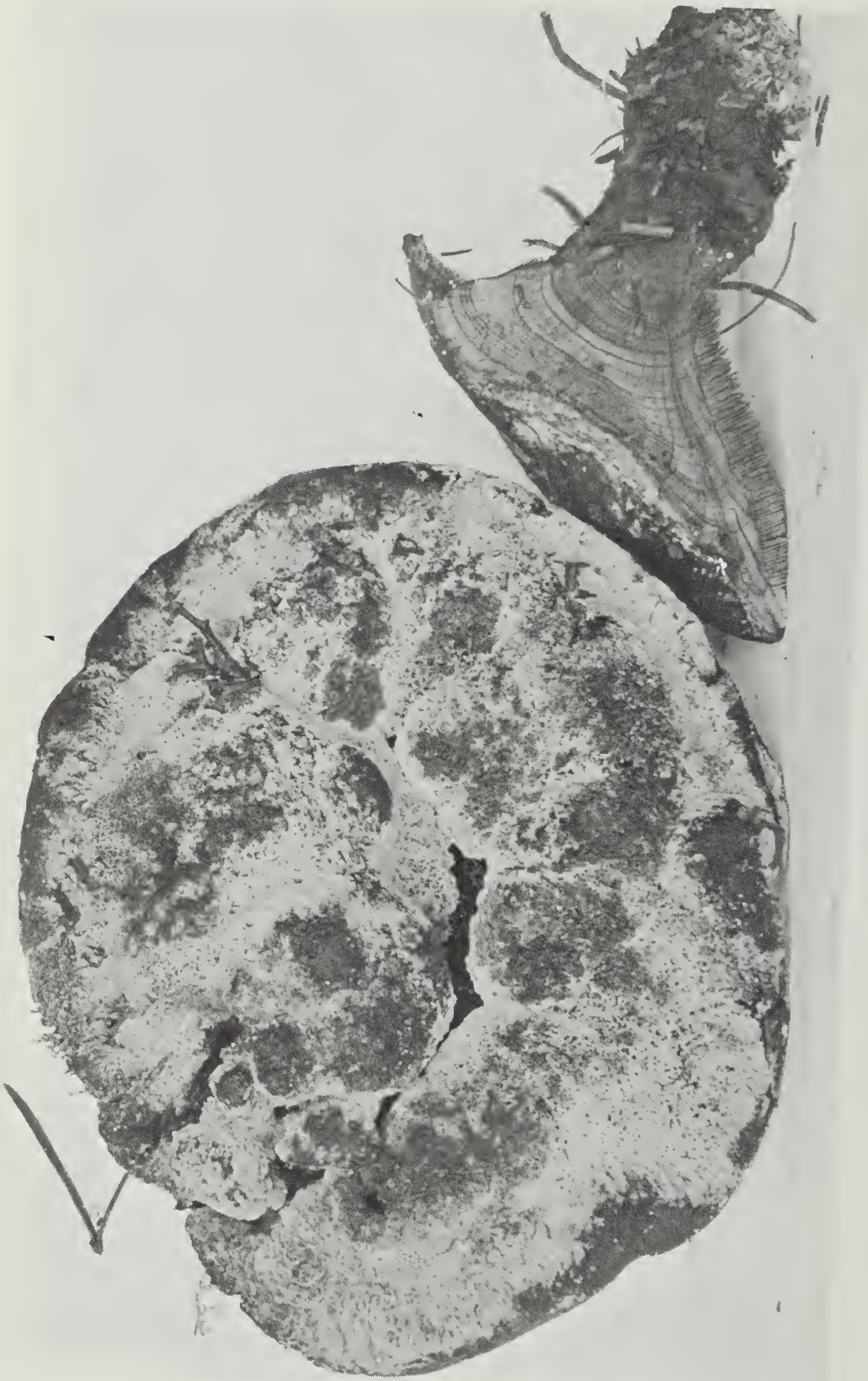

Fig. 20. *Hydnellum pineticola* ×1 Smith 38579

Fig. 21. *Hydnellum peckii* ×1 Smith 23699

Fig. 22. *Hydnellum cumulatum* ×1 Smith 72317

Fig. 23. *Hydnellum scrobiculatum* var. *scrobiculatum* ×1 Smith 64028

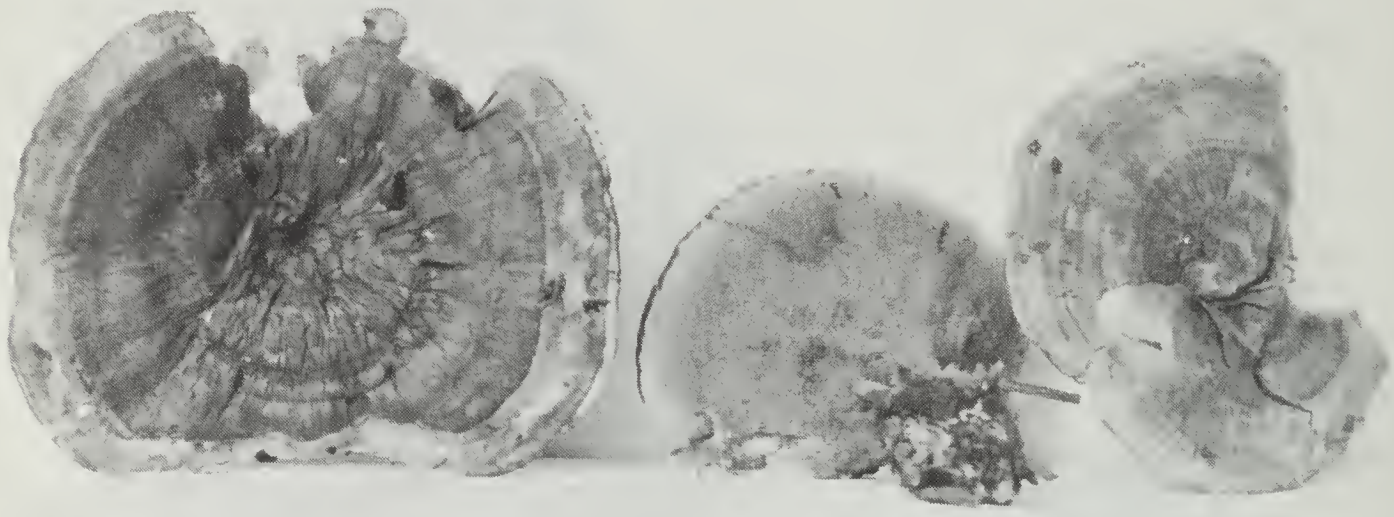

Fig. 24. *Hydnellum scrobiculatum* var. *zonatum* x1 Smith 64059

Fig. 25. *Hydnellum scrobiculatum* var. *zonatum* x1 Smith 64631

Nature education feature --

CONTACT DERMATITIS CAUSED BY PLANTS[1]

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The major plants causing contact dermatitis are in the genus *Toxicodendron* (often included in the more comprehensive sumac genus, *Rhus*). These include, in the midwest and eastern United States, poison ivy (*Toxicodendron radicans*) and poison sumac (*Toxicodendron vernix*). In the southeastern United States there is also poison oak (*Toxicodendron quercifolium*), and on the Pacific side of the country there is the western poison oak (*Toxicodendron diversilobum*). While there are species differences, to a patient these are probably incidental. These plants all presumably contain the same antigen, namely, pentadecylcatechol.

Other plants contain the same or a closely related toxin, urushiol. The hull of the cashew nut and, in fact, all of the anacardiaceous family of plants have this resin. It is also found in the hull or skin of the mango of Florida and the tropics. The lacquer tree (*Toxicodendron vernicifera*), from which the Japanese have long made beautiful lacquer ware, has the same antigen. This tree was introduced into Japan from China, where it is native, and where the Chinese in addition used the fruit of the ginkgo tree as a base for lacquer. The pulp of the seed of this tree acts as a primary irritant, and epidemics of contact dermatitis have been traced to areas where students have walked under a ginkgo tree and stepped on the plumlike seeds.

Physicians are aware that a host of other plants *may* produce contact dermatitis, but not by the same antigen, in sensitive persons. The wild carrot or Queen Anne's lace (*Daucus carota*) is one example. A trip to the country and back to nature in which children or adults pick buttercups (*Ranunculus* species) may result in a contact dermatitis. These plants contain a substance called anemonin which may cause blistering. Mayapple (*Podophyllum peltatum*), particularly the root, stem, or rhizome of the plant which contains podophyllin (a cytotoxin), may cause contact dermatitis. Dermatologists use podophyllin in the treatment of verruca acuminata and seborrheic keratoses, and some work has been done using podophyllin resin in the treatment of skin cancer.

The lady-slipper genus (*Cypripedium*) of wild orchids have long been a much admired group by naturalists. With the increasing use of our state parks and wilderness areas, these plants are found by persons who feel compelled to "pick the pretty wild flowers" or attempt to take the plants home. Lady-slippers can be admired and photographed, but should not be handled. Any of our

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[1] Reprinted by permission, and with slight revisions by the author, from *The Journal of the American Osteopathic Association* 64: 1023-1029 (June 1965). Much of this material was also included in an illustrated talk before the state meeting of the Michigan Botanical Club at the Cranbrook Institute of Science, March 17, 1968.

species may produce a toxic reaction. (Furthermore, in Michigan all orchids are protected and it is unlawful to pick them.)

Some cultivated plants also cause reactions. Often involved is the *Euphorbia* group. The juice of one species, white-margined spurge, grown as an ornamental, "snow-on-the-mountain" (*Euphorbia marginata*), "has been used for branding cattle in preference to a hot iron." (Kingsbury, 1964) Chrysanthemums contain pyrethrumlike substances which may be antigenic. Primrose (*Primula*) is another of the flower garden plants that may produce contact dermatitis; potted plants have even become an occupational hazard for nurses in hospitals. The rhizome or rootstock of iris may irritate some people. Lily-of-the-valley (*Convallaria majalis*) not only contains a digitalislike substance but also may produce dermatitis.

However, poison ivy, the poison oaks, and poison sumac produce the major portion of contact dermatitis from plants. There is much folklore about poison ivy, and much of it is unreliable. Reported treatments for the dermatitis range from fuming nitric acid to marshmallows and cream. The supposition that the serum of the dermatitis carries the antigen is false. The uninjured leaf of poison ivy, oak, or sumac does not emit the toxin, as the plants do not have hydathodes (special groups of cells which excrete fluid—which appears like dewdrops on plants such as tomatoes when humidity is high).

The flowers of poison ivy are small, in clusters, and often unisexual. The pollen is one part of the plant which does not contain the allergen. The fruit, less than a quarter-inch in diameter, is a dryish ivory drupe, readily found throughout the fall and winter. (A drupe is a fleshy fruit the seeds of which are contained in a hard "pit," as in peach and cherry.) The waxy flesh around the pit is relatively scant but enough to attract and be eaten by over 60 species of birds, which relish the fruit as winter food. The pits or "seeds" pass through the bird's digestive tract with only the flesh being removed; the viable seed remains intact, germinates, and the bird has helped disseminate poison ivy. Poison ivy is often profuse along fencerows and near bird feeders or where birds are fed in the winter.

There is no real substitute for recognition of these plants. This, of course, leads to avoidance, which is the best prophylaxis. The potential antigenic effect is phenomenal. Kligman (1958a) had a patient who was not sensitive to the toxin of poison ivy apply crushed leaf to his thumb. The thumb was applied to a nonsensitive person in a new area each time for a total of 500 times. The pressure each 100th time was applied to a highly sensitive individual. The sensitive skin reacted at all five sites of pressure. Even the 500th pressure caused a reaction to the infinitesimal quantity transmitted. A second study was done in which the juice of a crushed leaf was applied to sensitive individuals. It was allowed to remain in contact varying lengths of time—5, 10, 30, and 60 minutes— and the skin was then washed with Ivory soap for two minutes. In highly sensitive persons, after five minutes the fixation was complete and could not be altered; subsequently, dermatitis developed.

The use of soap and water, therefore, is in a questionable position. Its use will reduce the incidence of transfer but not remove the antigen in its entirety,

only the excess. Washing with equal parts of acetone and alcohol or U.S.P. semisolid green soap did not affect the removal of the antigen. The antigens of other plants have not been as thoroughly studied, but a good cleansing with soap is a help only to remove excess antigen.

The transfer of antigen should be considered. Cats and dogs are pets often involved; they may carry the toxin on their fur and transport it to humans. Persons who have an allergy to pentadecylcatechol may develop dermatitis from contact with their pet's fur, without leaving the house. Fireplace wood that has been contaminated by vines or leaves of poison ivy is another source. Smoke may be a vector which precipitates either directly on the host or on tools and clothing. Contaminated wood, golf balls, shoes, car tires, clothing, and lawn mowers are other means of transmitting the material. The pentadecylcatechol deteriorates slowly. Thorough laundering will remove it from washable clothing. On gloves, shoes, and clothing not laundered the resin will undergo oxidation, polymerization, and deterioration in a moist atmosphere more rapidly than in a dry one.

If the plant is intact and there is no escape of the resin, the antigen is not on the surface of the leaf. It is only when the leaf is traumatized or injured that the sap containing the antigen is present. The trauma may be minimal, from brushing or bruising the plant or from injuries produced by insects. Perhaps we do not think of this plant as being attractive to insects, but it is palatable and many of the leaves will show insect damage. The trauma to the plant as one walks by and injures the leaves and stems or as one treads on it and it springs back tends to encourage contact with the resin. There has been speculation that some fungi may cause enough injury to allow escape of the catechol. A microscopic examination of poison ivy shows that the resin ducts are large in proportion to those of many other plants, but no suggestion can be found that poison ivy, oak, or sumac is any more brittle than other plants. Nor has there been any suggestion that the resin is under unusual pressure in the ducts.

Protective creams, lotions, etc., are not prophylactically effective to prevent contact. In fact, oils and creams enhance absorption and help the dissemination of pentadecylcatechol, which is dispersed in the oil base residues. There has been much proprietary advertisement about oral desensitization with poison ivy extract, alum-precipitated. The material is inert, and there is no clinical or patch test evidence of poison ivy desensitization (Wechsler, 1964).

Once the allergen has joined with the protein of the skin, what is the therapy of choice? This, of course, depends upon the potential quantity of allergen on the skin. As mentioned previously, washing with soap removes only that antigen not already fixed in the tissue (the type of soap is incidental). Also, some type of compress can be used, the character depending on the experience of the prescribing doctor. Beyond simple compresses or a mild lotion no therapy is recommended. A physician should be consulted and his orders followed.

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NOTE: There are many additional sources of reading available in medical libraries and in some public libraries.

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ADDITIONAL WISCONSIN RECORDS FOR THE EBONY SPLEENWORT, *ASPLENIUM PLATYNEURON*

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Asplenium platyneuron (L.) Oakes has previously been known from only two Wisconsin counties: Dane (Tryon et al., 1953) and La Crosse (Hartley, 1959). Fell (1955) cites several localities in Winnebago County, Illinois, just south of the Wisconsin state line. In conjunction with the present study I have examined specimens in the following herbaria: University of Wisconsin, Milwaukee Public Museum, University of Wisconsin–Milwaukee, Beloit College, and Milton College. Specimens of the following collections are deposited in the herbarium of the University of Wisconsin, Rock County Campus, Janesville.

I have collected *Asplenium platyneuron* at two sites in Rock County, Wisconsin. In Magnolia Township, T3N, R10E, two individual plants were found in October 1967 in a white birch–mixed oak woods on a north-facing sandstone slope in the county park east of Croak Road, SE 1/4 of section 18 (Musselman 1592). Repeated visits to this area have failed to reveal additional plants.

On January 22, 1968, I encountered a population of approximately 22 individuals in a smooth sumac thicket on a well eroded east-facing sandstone slope in the NW 1/4 of section 23, Plymouth Township, T2N, R11E (Musselman 1659).

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THE MILTON COLLEGE HERBARIUM

Lytton J. Musselman
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The herbarium of Milton College, Milton, Wisconsin, contains an extremely valuable collection of several thousand specimens of vascular plants and cryptogams which has apparently escaped notice during the past seventy years. The existence of the collection was recently brought to the author's attention in connection with floristic studies in southern Wisconsin. The collection is of more than passing interest to Wisconsin botanists since it contains many species now extremely rare or extinct in southern Wisconsin and may provide additional locality records for persons working on the state flora.

The Milton collection consists largely of specimens either donated by or purchased from a Mr. S. H. Watson, a little known Wisconsin botanist active from ca. 1859-1862. All of his collections were made in southern Wisconsin and are valuable indicators of a bygone vegetation. Several orchids and other plants now nearly extinct in southern Wisconsin are noted by Watson as being "common" or "not rare." Although most of his collecting was done in Dane County (largely Dunkirk Township but also Madison, Pine Bluff, and Blue Mounds) it is not mentioned by those who have studied the flora of Dane County (Cheney and True, 1893; Ellarson, 1949). Occasional specimens are from Rock County (Janesville, Fulton, Porter, and Union Townships); Iowa County (vicinity of Arena), and Sauk County (bluffs of the Wisconsin River). His labels simply read "S. H. Watson, Madison, Wis." with the name of the plant, location (usually very general), and year of collection. Few of Watson's specimens are in any Wisconsin herbaria other than the herbarium of the University of Wisconsin (Madison) which received several hundred Watson collections from the Academy of Natural Sciences of Philadelphia about ten years ago.

Pennell (1935) in his listing of collectors of Scrophulariaceae, includes S. H. Watson as having specimens deposited in the herbarium of the University of Michigan. No mention is made of any Wisconsin herbarium.

Mr. Watson apparently collaborated with his better known fellow-botanist, T. J. Hale. Hale cites several Watson specimens in his papers on the flora of Wisconsin (Hale 1858, 1860). Several of Watson's labels read "Ex. Coll. T. J. Hale." Hale had several of his specimens identified by D. C. Eaton, a prominent botanist of the period.

The Milton collection is rich in specimens from the collection of the well known botanist of Watson's day, Wm. Canby. Other collectors represented by a lesser number of specimens than those of Canby include Increase A. Lapham and T. J. Hale (Wisconsin); George Vasey, Samuel B. Mead, Michael S. Bebb, Elihu Hall (Illinois); Mary H. Clark (Ann Arbor and Detroit areas of Michigan); C. M. Short (Kentucky); and H. Jackson (Pennsylvania and Maryland). Worthy of note are a few specimens of *Carex* from the collections of Schweinitz and Torrey. In addition there are a few specimens deposited by staff members and students of

Milton College about the turn of the century. The source of the older specimens is a matter of conjecture. They may have been gathered by Watson or by a member of the Milton College staff. However, evidence seems to point to their acquisition by S. H. Watson since duplicates of many of the above collectors were found in Madison newspapers dated 1860-1862.

Despite an absence of care and a century's deposition of coal dust, the collection is in excellent condition. Fortunately, many duplicates are available and are being distributed to Wisconsin herbaria.

It is hoped that Wisconsin botanists will now avail themselves of the use of this collection. Facilities and staff are not available for the loaning of specimens. Persons interested in examining the collection should contact the author or Professor L. M. Van Horn, Chairman, Department of Biology, Milton College, Milton, Wisconsin 53563. The symbol suggested for the next edition of the Index Herbariorum is MCW.

ACKNOWLEDGMENTS

I am indebted to L. M. Van Horn, J. L. Skaggs, and A. L. Millard for their assistance.

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Editorial Notes

INDEX: The Michigan Botanist has published a three-year index at the end of Vol. 3 and of Vol. 6, in the expectation that each three-volume unit would be a better size for binding. No index is issued now for Vol. 7, but there will be another cumulative one at the end of Vol. 8 or 9.

The May number (Vol. 7, No. 3) was mailed May 25, 1968.

Program Notes

March 16, 1969: State membership meeting, Michigan Botanical Club.

May 23-25: State membership meeting and annual Spring Campout, Michigan Botanical Club: near Irons, Lake Co., in the Manistee National Forest.

News Notes

PUBLICATIONS: Since it appeared in 1940, Deam's *Flora of Indiana* has stood as one of the finest state floras ever produced. Out of print and extremely scarce on the secondhand market, it is now being reprinted by J. Cramer, Publisher (P.O. Box 48, D-3301 Lehre, Germany). Subscription price is $20.00; after publication, the price will be $25.00. . . . The Michigan Department of Conservation (now Michigan Department of Natural Resources), due to lack of funds, is unable to reprint its excellent county maps. The complete books have been out of print for a year; some individual counties are still available.

HONORS TO OUR FRIENDS: Genevieve Gillette, founder and president of the Michigan Parks Association (and honorary member of the Michigan Botanical Club) was one of five persons in the nation to receive an award this year for contributions to a "Beautiful America" from Holiday Magazine, which described her as "conscience for the nation's landscape." Michigan Governor George Romney presented the "golden tree" award to Miss Gillette, who is also a member of President Johnson's Citizens Advisory Committee on Recreation and Natural Beauty. In 1966 she was named forest and park conservationist of the year by the National Wildlife Federation and the Sears Roebuck Foundation in cooperation with the Michigan United Conservation Clubs. . . . Dale J. Hagenah, research associate with the Cranbrook Institute of Science, now has a fern named for him. *Polystichum* x *hagenahii,* the hybrid between *P. acrostichoides* and *P. lonchitis,* was published by W. J. Cody in the American Fern Journal for January-March 1968. . . . Dr. Harold B. Tukey, Sr., who retired in 1962 as chairman of the Department of Horticulture at Michigan State University—where he sat at Liberty Hyde Bailey's old desk—received the Liberty Hyde Bailey Medal of the American Horticultural Society for 1968. Also honored by the A.H.S. was former Michigan Stater and Botanical Club member F. L. S. ('Steve') O'Rourke, now at Colorado State University, who received a Citation from the Society. . . . Dr. Stanley A. Cain returned in August to his duties at the University of Michigan as Professor of Conservation and of Botany, after serving since February 28, 1965, as Assistant Secretary of the Interior for fish, wildlife, and parks. . . . And the Michigan Botanical Club received the award as conservation organization of the year at the annual convention of Michigan United Conservation Clubs at Sault Ste. Marie in June. Past president Charles Barclay accepted the award on behalf of the Club.

IN MEMORIAM: Shirley W. Allen, honorary member of the Botanical Club and an early leader in the Michigan Natural Areas Council, died September 12, 1968, in Ann Arbor, at the age of 85. Mr. Allen was professor emeritus of forestry at the University of Michigan. . . . Dr. John H. Ehlers died in Colorado November 17, 1967, two weeks after his 99th birthday. Dr. Ehlers taught systematic botany at the U. of M. Biological Station on Douglas Lake from 1916 to 1938, in addition to his Ann Arbor teaching and service as Curator of Phanerogams in the Herbarium, and was one of the most prolific of Michigan plant collectors.

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(On the cover: Sporophytes of the 'bug-on-a-stick' moss, Buxbaumia aphylla *Hedw., photographed in an aspen stand at the University of Michigan Biological Station by Norton G. Miller, July 28, 1968.)*

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Articles and notes dealing with any phase of botany relating to the Upper Great Lakes Region may be sent to the editor in chief. The attention of authors preparing manuscripts is called to "Information for Authors" (Vol. 6, p. 202; reprints available from the editor).

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Membership in the Michigan Botanical Club is open to anyone interested in its aims: conservation of all native plants; education of the public to appreciate and preserve plant life; sponsorship of research and publication on the plant life of the State; sponsorship of legislation to promote the preservation of Michigan native flora and to establish suitable sanctuaries and natural areas; and cooperation in programs concerned with the wise use and conservation of all natural resources and scenic features.

Dues are modest, but vary slightly among the chapters and with different classes of membership. Persons desiring to become state members (not affiliated with a local chapter) may send $3.00 dues to the Membership Chairman listed below. In all cases, dues include subscription to THE MICHIGAN BOTANIST. (Persons and institutions desiring to subscribe without becoming members should deal with the business and circulation manager as stated at the top of this page.)

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POLLEN ANALYSIS AT THE THALLER MASTODON SITE, GRATIOT COUNTY, MICHIGAN

Edith R. Held and Ronald O. Kapp
Luther College, Decorah, Iowa, and
Alma College, Alma, Michigan

INTRODUCTION

While digging an irrigation pond on his farm in June of 1965, Louis Thaller discovered mastodon bones (SE¼, NE¼, NE¼, sec. 18, T 12 N, R 4 W, Gratiot Co., Michigan). Excavation was undertaken by the landowner and a preliminary study of the site and bones was made by biologists from Central Michigan University (Mahan & Whitney, 1966). Samples of peat and wood were collected by the junior author for radiocarbon dating and pollen analysis. The results of this investigation permit the reconstruction of the vegetation associated with *Mammut americanum* (Kerr), the American Mastodon, and are reported here.

The bones were embedded in gray sand immediately above the glacial till. The remains include:

20 ribs	1 ulna
1 femur	7 vertebrae
1 patella	1 complete hyoid apparatus
1 fibula	1 right (?) tusk (broken)
1 set of foot bones	2 third molars
1 humerus	1 second molar

The molars were deeply worn with the cusps almost removed on the third molars; the second molar was highly polished and deeply concave. The size of the tusk and femur, the deeply worn molars, and the elevated and roughened muscle and ligament insertions, all indicate that this was an old animal.

SITE DESCRIPTION

The depositional basin is elliptical, about 100 x 200 yards (90 x 180 m) in extent, and oriented along an east-west axis. Peat occurs to a depth of 80 cm; beneath a transitional zone, gyttja occurs from 100 to 105 cm; there is silty gyttja from 105 to 135 cm, and sand from 135 to 150 cm (Fig. 1). Samples were collected for C-14 dating from the same channel section from which pollen analytical samples were taken.

The poorly-drained depression apparently contains no more than 2 meters of accumulated sediments; it is surrounded by low sandy hills. Deposition is no longer occurring but water stands in the center of the marsh during the spring and early summer. The vegetation of the marsh is dominated by *Carex, Typha,* various grasses, *Eupatorium,* and *Verbena. Alnus rugosa, Spiraea alba,* and several species of willow (*Salix* spp.) form the dominant shrub cover fringing the marsh; occasional red maple (*Acer rubrum*) and trembling aspen (*Populus tremuloides*), and a single tamarack (*Larix laricina*), are present in the basin.

Second-growth and selectively cut woodlands near the excavation site, and at Lumberjack Park in the same section, provide an indication of the composition of the upland forests that surrounded the depositional basin before settlement. Well-drained sandy sites are dominated by white pine (*Pinus strobus*), with occasional hemlock (*Tsuga canadensis*), big-toothed aspen (*Populus grandidentata*), and white oak (*Quercus alba*); the understory is dominated by witch hazel (*Hamamelis virginiana*) and juneberry (*Amelanchier* sp.). On more poorly drained sites red maple (*Acer rubrum*) is dominant, with white pine and paper birch (*Betula papyrifera*) frequent; red oak (*Q. borealis*), white oak, swamp white oak (*Q. bicolor*), wild black cherry (*Prunus serotina*), sugar maple (*Acer saccharum*), and hemlock are occasionally present. These observations and previous studies of the presettlement forests in nearby Richland Twp., Montcalm Co. (Hushen, et al., 1966), indicate that the area was originally heavily forested

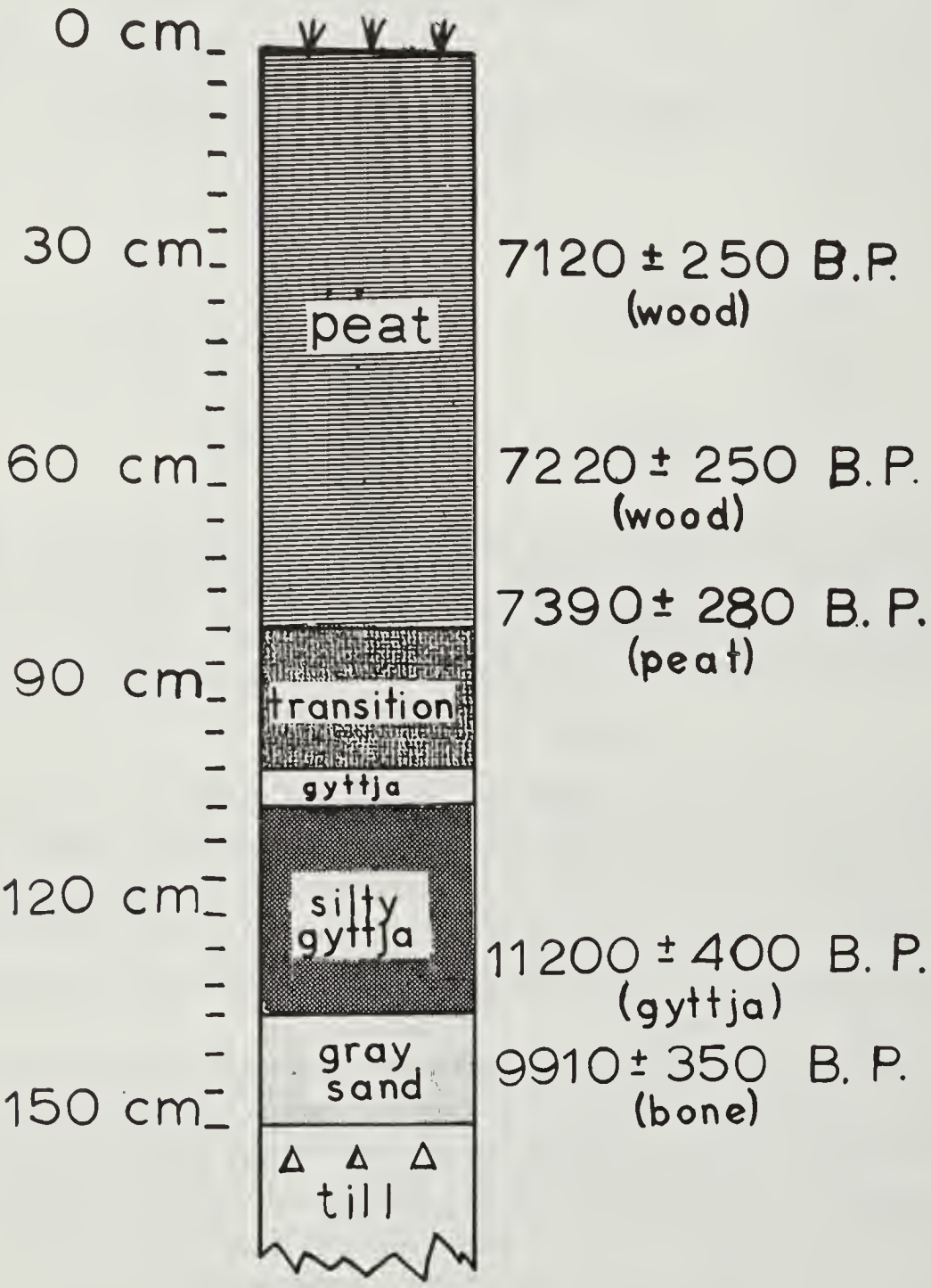

Fig. 1. Sedimentary sequence at the Thaller mastodon site. Left column shows depths of the samples analyzed; C-14 dates are shown at the right at the appropriate depths.

with white pine; mixed hardwood and hemlock forests occupied moist sites in presettlement times.

METHODS

Samples were collected from the exposed face of the excavation at 5 cm intervals to a depth of 150 cm. Samples for pollen analysis were placed in glass vials in the field; the open vials were pushed into the freshly exposed sediments to prevent contamination. Peat and wood samples were sealed in polyethylene bags.

Calcareous samples were flooded with 6% HCl to remove carbonates. All samples for pollen analysis were processed according to the standard acetolysis procedure (heated to boiling in 9:1 mixture of acetic anhydride and concentrated sulfuric acid) and the concentrated residue was suspended in glycerine jelly for storage and slide preparation.

Pollen counting was performed at 100 diameters magnification due to the high percentage of pine and spruce; small or difficult entities were studied at 450 or 950 X. Counting was continued along regular traverses of the mechanical stage until approximately 200 pollen grains (excluding sedges and aquatic plants) had been tallied. At 140 cm a full count was not tallied because, possibly due to a rapid rate of sedimentation, pollen grains were very scarce. At 145 and 150 cm pollen was absent.

RESULTS

The results of pollen analysis are presented in the pollen diagram (Fig. 2), which includes those entities which are consistently or abundantly represented in the samples. Cyperaceae (sedge) and aquatic species, which are of restricted distribution near the depositional site and are frequently overrepresented, are excluded from the pollen sum. Percentage frequencies are based on the pollen sum and are plotted for each stratigraphic level and then connected vertically to give a pollen profile for each of the pollen types. Frequencies of Cyperaceae, aquatic plants, and ferns are calculated as percentages of the pollen sum, even though they are excluded from the sum. Percentages of infrequent pollen and spore types are shown in Table I. Of particular interest in this table is the occurrence of *Tilia* and *Tsuga* throughout the record and the identification of a single grain of *Linum* (flax) pollen from the 140 cm level.

Samples of wood collected from the peat zone were identified by microscopic examination. Three types were recovered: *Pinus strobus, Picea* sp., and *Fraxinus* sp.

Radiocarbon dates on samples of peat, wood, and mastodon bone (inner tusk) are given in Fig. 1.

DISCUSSION

There is a general trend from high (greater than 50%) to lower (less than 30%) spruce pollen in the record. This is similar to other sequences from Michigan which typically have an early *Picea*-dominated zone which began soon after deglaciation and ended between 8,000 and 10,000 years B.P. (Andersen, 1954;

Zumberge and Potzger, 1956; Gilliam, et al., 1967; Kapp, ms.).

Characteristic of the Spruce Pollen Zone are high percentages of *Picea* and nonarboreal pollen (NAP). *Abies* is present only in this zone; this is consistent with other late-glacial pollen records from Michigan. The Thaller diagram has significant percentages of *Ambrosia* and *Artemisia* in the Spruce Pollen Zone; these herbs, along with some of the composites (Compositae) and grasses (Gramineae), probably occupied ecologically disturbed and open habitats within the spruce forest.

The Pine Pollen Zone (Zone II, Fig. 2) is characterized by high percentages of pine and fern spores and low percentages of spruce and NAP.

Typically, a Hardwood Pollen Zone follows the Pine Pollen Zone in pollen diagrams from the region. At Vestaburg Bog, only 6 miles from the Thaller farm, the Hardwood Pollen Zone begins about 8,000 B.P. and is characterized by high percentages of *Quercus* and other hardwood pollen types. In the Thaller pollen diagram the Hardwood Zone is subdued by local overrepresentation of pine and spruce pollen. Black spruce (*Picea mariana*) apparently persisted after the beginning of the postglacial period at about 10,000 B.P. and probably increased in cover; this is reflected in the increase in the spruce pollen percentages (from 45 to 5 cm). The high pine pollen frequency in Zone II is due to the abundance of white pine on the surrounding hills; a similar forest composition persists to the present at nearby Lumberjack Park (located ¾ mile southwest of the site) and at nearby Thaller's woods. The postglacial persistence of spruce at the site, and the local occurrence of white pine, is confirmed by the discovery of wood of these trees in the peat zone.

Modern pollen rain studies from moss polsters in Thaller's woods have yielded pollen spectra with high pine and low hardwoods (Fig. 1, upper spectra). *Picea* is much less prominent in the modern pollen rain when compared with the period 7,300-7,100 B.P.; spruce trees are now very infrequent in this vicinity. The stand of spruce in the Thaller peat bog must have disappeared subsequent to the time that deposition ceased. Comparison of the modern and fossil pollen spectra substantiates the foregoing interpretation of the Pine Pollen Zone and explains the paucity of the hardwoods in the record.

Ecological succession gradually changed the site from lake to bog to a seasonally wet marsh. The presence of *Sagittaria* and *Nuphar* in the lowest level substantiates the existence of a small shallow lake in late-glacial time. The change from lake to bog is inferred from the changing composition of the sediments. Gray sand and gyttja immediately above the glacial till indicate the presence of an alkaline lake; the gradual transition to peaty gyttja and subsequently peat reflects the change to bog, and later marsh, conditions. A substantial increase in the frequency of fern spores in the upper zone is probably related to increased dryness associated with this succession. Sediments stopped accumulating when the bog filled in completely about 7,000 years B.P.

Gilliam, et al. (1967) conclude that *Tsuga* migrated into Montcalm County about 8,000 years B.P.; yet *Tsuga* was present in the Thaller farm about 10,000 B.P. (120 cm). Assuming that *Tsuga* could not have entered Michigan from the south because of the presence of the prairie peninsula (Benninghoff, 1964),

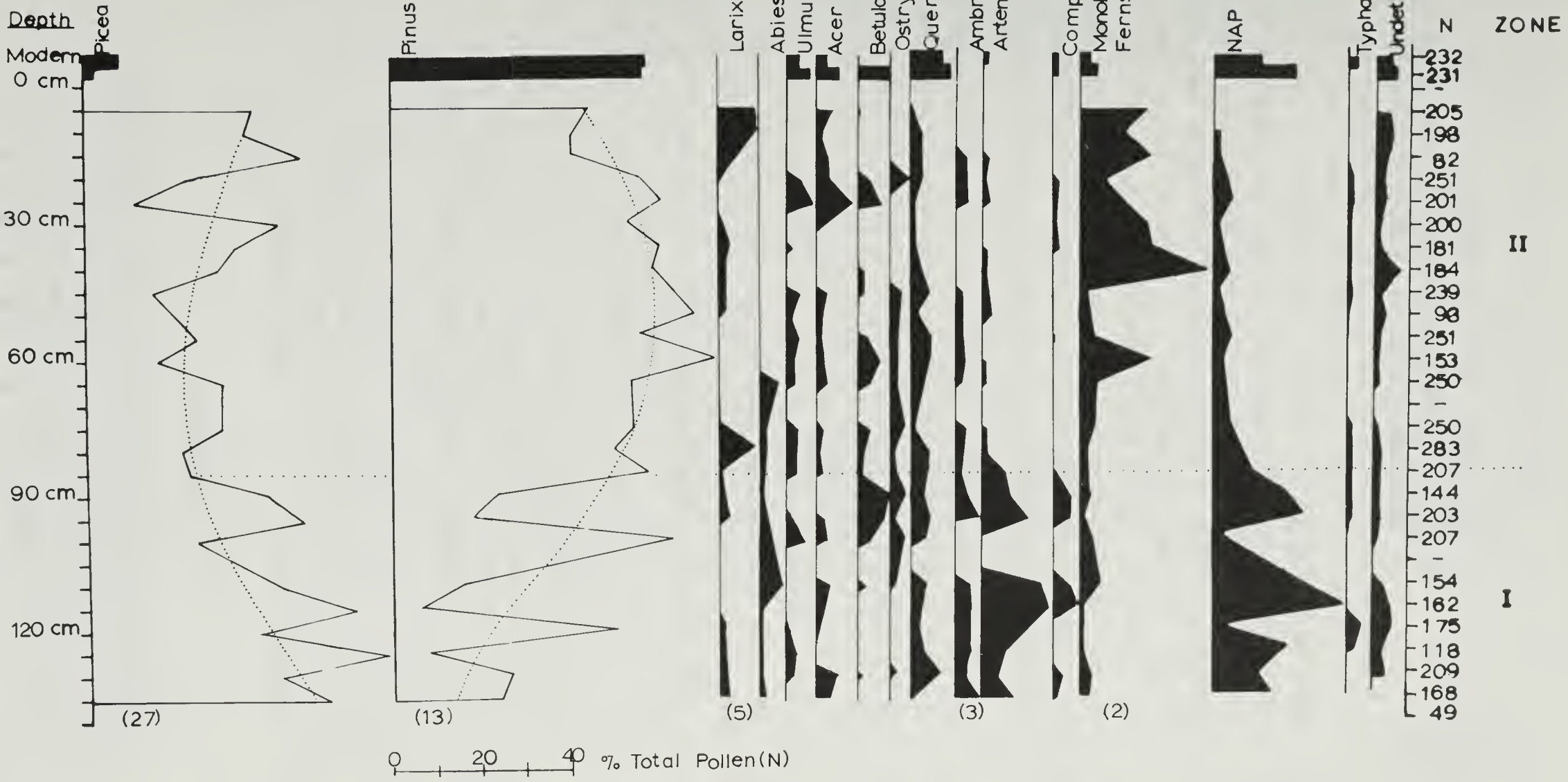

Fig. 2. Pollen diagram from the Thaller mastodon site. Total pollen tabulated for all entities except sedges (Cyperaceae) and aquatics is shown in the right column (N); this sum was the basis for calculating the percentages in each fossil and modern pollen spectrum. Two modern pollen spectra are plotted at the top; the uppermost is from a moss polster in an upland, second-growth white pine stand; the lower is from a polster in a lowland pine-mixed hardwood stand.

TABLE I. Occurrence of infrequent pollen and spores in sediments from the Thaller mastodon site; figures are percentages of the total pollen sum.

Depth (cm)	Tsuga	Cupress. -Taxac.	Carya	Fagus	Fraxinus	Juglans	Populus	Tilia	Alnus	Salix	Corylus	Cheno.- Amar.	Gramin.	Cyperac.	Typha Sparg.	Trilete spores	Osmunda	Others	
5	0.2	2.9						0.5		1.0	0.5		1.0	0.5	1.9		4.9		
10	2.5	2.5				0.5			0.5	1.5						1.5	2.5		
15								1.2		1.2				1.2		1.2	3.7	Pediastrum	2.4
20					2.0			1.2										Castanea	1.2
25										1.0		0.5		0.5		0.4		Selaginella	0.4
35		0.6									0,6					1.1	1,1		
40													2.9			2.9			
45		0.8			1.3						2.5					0.8			
50	1.0										2.0	0.8	1.2						
55			0.8		1.2	0.8		0.4			0.8	0.4				0.8	0.4	Cruciferae	1.2
60																0.7	0.7		
65						0.4					0.4					0.4	0.4	Selaginella	0.4
75					0.4	0.8					0.4		0.8	0.8		1.2	2.7	Cruciferae	1.2
80		5.7			0.7		1.4			0.4	1.4	0.4	0.4		0.7			Cruciferae	0.8
85		0.5	0.5		0.5					0.5	0.5	0.5				0.5		Pteridium	0.4
90						0.7			3.8					0.7			0.7	Equisetum	2.8
95				0.5					1.0			1.0	1.5			0.5		Cruciferae	1.2
100	0.5																	Celtis	2.1
110										0.7	0.7			0.7		0.7		Cruciferae	2.1
115											0.6	1.2						Vitis	0.7
120	2.4							0.6	1.2							3.5	2.9	Selaginella	0.7
125					1.7													Cruciferae	0.5
130					1.5	1.0			1.0	1.0		1.0	0.5			1.0		Ericaceae	0.7
135		1.2										0.6		1.8				Equisetum	0.6
140												2.0						Cruciferae	0.6
																		Ericaceae	0.6
																		Cruciferae	0.8
																		Cruciferae	1.4
																		Vitis	0.5
																		Selaginella	0.5
																		Sagittaria	0.5
																		Nuphar	1.9
																		Linum	0.6
																		Selaginella	0.6
																		Cruciferae	1.2

these central Michigan records suggest that hemlock entered the state from the east or north rather soon after deglaciation. *Fagus* pollen occurred at 95 cm (about 8,000 B.P.) and is consistent with other pollen diagrams from central Michigan. Gilliam also suggests that *Tilia* is a more recent addition to the flora, while the Thaller diagram indicates the presence of *Tilia* as early as 10,000 years B.P. (120 cm).

The radiocarbon dates of the peat, wood, and gyttja (30 cm, 7,120 ± 250 years B.P. on wood, M-1740; 60 cm, 7,220 ± 250 on wood, M-1741; 80 cm, 7,390 ± 280 on peat, M-1742; 130 cm, 11,200 ± 400 on marly gyttja, M-1743) are in stratigraphic sequence and are accepted as accurate. Different rates of sedimentation are indicated for the gyttja and peat, however. The gyttja (after compaction) apparently accumulated at a rate of approximately 1.3 cm/100 years while about 18 cm of peat were forming per 100 years (Fig. 1).

The C-14 date on mastodon tusk (9,910 ± 350 B.P., M-1739) is open to question since it lies stratigraphically beneath the gyttja, but dates younger. While the possibility that the bones were intruded into the deeper sediments cannot be conclusively disproved, because of the shallowness of the deposit and method of excavation, we believe that they were covered *in situ.* The bones were embedded in compact sand, lying on glacial till without evidence of peat or gyttja beside or beneath them. In other instances radiocarbon dates on mastodon bones have been shown to be too young. Skeels (1962) reported an instance of erroneous dating due to the penetration of modern plant roots; Kapp (ms.) concluded that mandible and tusk dates for the Rappuhn mastodon were too young in an excavation where there was good stratigraphic control and a consistent series of other radiocarbon dates.

These observations suggest that radiocarbon dates on mastodon bones need careful scrutiny. Previous conclusions regarding the time of extinction (ca. 6,000 B.P.) are almost certainly too young and will require reinterpretation. Although corroboration is necessary, we suggest that mastodon extinction occurred very soon after the beginning of postglacial time, probably in response to climatic changes and alteration of the favorable late-glacial ecosystems. The role of man (Martin, 1967) in these ecosystem alterations is uncertain.

This pollen record, and apparently all others in which the vegetation associated with mastodons has been analyzed, indicates that the American mastodon was a member of glacial and late-glacial ecosystems in eastern North America. This was a period of cool-moist climate. Pollen records from this period in the Great Lakes region are dominated by spruce pollen, but the presence of hardwood pollen probably indicates a variable mosaic of conifers and hardwoods. We tend to accept the hypothesis of Brown and Cleland (1968) that the mastodon required both a cool-moist climate and a plant community which included woody angiosperms.

SUMMARY

The vegetational patterns associated with the Thaller Mastodon correspond with existing Michigan pollen records, but with minor differences. The Spruce Pollen Zone extended from deglaciation to about 8,000 years B.P. and the Pine Pollen Zone continued until deposition ceased at about 7,000 B.P. The typical Hardwood Pollen Period is obscured by local overrepresentation of pine and spruce pollen. Spruce, white pine, and ash wood

were embedded in the peat which was deposited during the Pine Pollen Period at the site. This explanation is confirmed in modern pollen rain studies from moss polsters near the site.

Radiocarbon dates of peat, wood, and gyttja range from 7,120 ± 250 B.P. to 11,200 ± 400 B.P. The date (9,910 ± 350 B.P.) on the bone is open to question because it was lying in sand stratigraphically lower than the gyttja, yet the bone has a younger date.

ACKNOWLEDGMENTS

These investigations were supported by the National Science Foundation-Undergraduate Research Participation program (Grant GY-2871). Appreciation is extended to the Michigan Memorial Phoenix Project Radiocarbon Laboratory for providing the C-14 dates. Thanks are extended to Mr. and Mrs. Louis Thaller for their continuous cooperation. The facilities of the Department of Biology, Alma College, were used throughout.

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Review

LIVING WITH YOUR LAND A Guide to Conservation for the City's Fringe. By John Vosburgh. Cranbrook Institute of Science (Bulletin 53), Bloomfield Hills, Michigan. 1968. 149 pp. $1.00 (plus tax).

Funds from the Garden Club of Michigan aided preparation of this excellent little paperback, which no intelligent and concerned citizen should be without. The book is designed for suburban dwellers in the Northeast, Middle Atlantic, and Midwest states, with the advice to them "not to dash ahead in a mad effort to conquer nature but to recognize the character of the natural landscape and to bend your plans to it." This comes as a refreshingly helpful and practical, surprisingly complete guide for dealing with native and introduced plants and animals which may live on or visit one's suburban premises. It suggests significant forms of community action to maintain or restore natural beauty and to educate the public. Appendices on where to find advice, help, and material are good but exceedingly short. Michigan is occasionally cited as an example and the Huron-Clinton Metropolitan Authority is specially mentioned.

–E. G. V.

AN ECOLOGICAL ANALYSIS OF A SOUTHERN MICHIGAN BOG

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INTRODUCTION

The term "bog" refers to a soil-vegetation complex made up of specialized herbs, and trees growing on a wet, acid peat soil.

Gates (1942, p. 217) defines a bog as

> . . . an area of vegetation, developing in undrained or poorly drained situations, which by the development of a mat invading open water, forms a cover over a body of water. It consists of a series of successional stages or associations beginning with mat-forming sedges and passing through shrub (mostly ericad) and Sphagnum stages to an expected culmination in the development of a characteristic coniferous tree association.

Rigg (1916, p. 310) says that a *Sphagnum* bog is

> . . . that stage in the physiographic succession of an area during which its surface is entirely devoid of ordinary "hard" soil, and is composed completely of living sphagnum moss under which is fibrous brown peat composed mainly or entirely of partially decayed sphagnum.

A bog generally has a high water table, but usually there is little standing water other than the associated bog lake. The upper peat and bog waters are typically strongly acid.

Bogs occur in depressions and lowlands. Many form in kettle holes in glacial moraines and in low spots in uplands. Bog conditions may develop in quiet bays of large lakes or stream channels. They are characteristic of cold regions with long winters and high rainfall. The shallow, little differentiated podzols of these regions often support a coniferous forest. Dansereau (1957, p. 87) cites these regions as ". . . the zone of bogs, par excellence, with their typical moss, sedge, and ericad flora: the tendency to peat accumulation is in evidence everywhere that drainage is impeded." The term "bog" is often loosely applied to any peat-covered land of cold, northern regions. However, bogs become scattered and less numerous as the major vegetational units of North America pass from the northern conifer forest, toward the glacial boundary, through the hemlock–white pine–northern hardwood tension zone, to the eastern deciduous forest.

Transeau (1905) noted that peat deposits of considerable extent occur occasionally south of the limit of Wisconsin glaciation. Many of these are believed to be associated with earlier glacial advances of the Pleistocene.

Bog formations associated with former localized glaciation are also known in the mountains of the eastern and western United States.

Other situations in which there is considerable peat accumulation are associated with coastal plain phenomena of eustatic movement, irregular depositions

of alluvial materials in deltas, and reef building causing extension of the land. In North America the greatest development of the southern bog condition is in eastern Virginia and North Carolina, Florida, and the Mississippi floodplain. The vegetation in these habitats is noted for its density and luxuriance and this combined with stagnant water allows peat formation in spite of high temperatures (Transeau, 1905).

Although these southern peat deposits are sometimes referred to as "bogs," they have a very different appearance from those to the north. In comparing the vascular plants of two sphagnous wetlands in New Jersey, Montgomery and Fairbrothers (1963) noted that the northern bog, located within the glacial boundary, had a floating mat encroaching upon open water and the peat was deep. The southern bog, on the other hand, located on the unglaciated coastal plain at the southern tip of New Jersey, had no floating mat and the peat deposit was shallow. The northern bog reflected a dominance of woody species in contrast to a chiefly herbaceous flora in the southern bog. The northern bog had a constant water level and continuous *Sphagnum* distribution, whereas the southern bog was characterized by fluctuating seasonal water levels and a scattered *Sphagnum* distribution.

Despite their differences, northern and southern bogs have a strong physiological similarity. Factors such as acidity, peaty soils, high water table, and the presence of a number of species with otherwise northern distributions suggest the possibility of southern bogs having served as refugia during Pleistocene times.

DESCRIPTION OF PENNFIELD BOG

The bog which is the subject of this study is located in Calhoun County, Michigan, 1¾ miles north of Pennfield and 7 miles northeast of Battle Creek. Pennfield Bog, as it will be referred to here, is associated with two adjacent lakes, Goose Lake and Little Goose Lake, each of which is 4 acres in area. During years of high water table the lakes are connected by a narrow channel of water filled with *Nuphar luteum* and *Nymphaea tuberosa.* They appear as two distinct lakes during years of low water table (as indicated by an aerial photograph made in 1961). The bog possesses all the features necessary to fulfill the bog definitions given by Rigg (1916) and Gates (1942).

Little Goose Lake, now owned and set aside as a plant preserve by the Eastern Michigan Nature Association, has had the greatest amount of bog development, being completely surrounded by a floating mat. This mat is most extensive to the northwest, the direction of prevailing winds.

Goose Lake has a floating mat on the northwest side, but although the lake shore is completely organic, there is virtually no floating mat on the southeast side of the lake. The only outlet of the bog is at the east corner of Goose Lake. It probably is functional only during periods of high water table. The shallow outlet runs a short distance into Deep Lake, a 7-acre lake also with a completely organic shore (Humphrys & Green, 1962).

Pennfield Bog, in one of the numerous depressions of the Kalamazoo end moraine of Wisconsin age, is at an elevation of 860 feet above sea level. The glacial till of the morainal system is generally sandy and is underlain by a

bedrock of sandstone (Leverett and Taylor, 1915). The glacial ice flow in the locality was that of the Saginaw ice lobe progressing from a northeast to a southwesterly direction (Flint, et al., 1959).

The morainal ridges surrounding the study area support various vegetation types. The northernmost ridge supports an oak woods and a small reforestation of red pine; the northwest side is pasture; the southwestern and southern border is an old orchard returning to an oak woods; the northeast ridge is a black oak-red maple woods.

CLIMATE

The climate of the region of Pennfield Bog is modified considerably by Lake Michigan, about 65 miles to the west. When there is little or no wind the climate is continental, but when there are strong winds from the Lake the weather becomes semimarine. Winter winds are warmed in transit across Lake Michigan and summer winds are cooled, thus creating a more moderate climate than that on the western side of the Lake. Spring temperatures tend to be depressed while fall temperatures are elevated (Eichmeier, n.d.).

Weather data for the Battle Creek area show the highest temperature recorded was 104°F in July 1936 and the lowest was -24° in February 1899. Days with 90° temperatures occur on an average of 20 per summer and the mean temperature of January, the coldest month, is 11.4°. The Climatological Survey (Eichmeier, n.d.) for the period 1926-1955 at the nearest weather station at Battle Creek shows the mean daily maximum temperature to be 58.6° for the year, while the mean daily minimum temperature is 38.8°. The warmest month is July with a mean temperature of 85.1°. The average dates of the last freezing temperature of spring and the first freezing temperature of fall are May 8 and October 9, respectively. In the fall of 1967 signs of frost were in evidence at Pennfield Bog about 20 days earlier than the average date recorded at the nearest station.

Precipitation averages 46% greater for the months May-October than for the rest of the year. May and June are the peak months with heaviest amounts of rainfall due to thundershower activity. Average precipitation ranges from a high of 4.04 inches in May to 1.73 inches in February with the annual mean at 33.43 inches.

Snowfall averages 39.8 inches during Battle Creek winters. The first snowfall usually occurs in November and the last in April, with an average of 57 days with snow on the ground.

Sunshine is only 30% of the possible total during January, while in the June-August period sunshine reaches about 70% of the possible amount.

Relative humidity averages of the summer season range from 78% in early morning to 50% in early afternoon while winter averages are 85%-75%.

WATER AND SOIL

The open lake waters of Pennfield Bog are neutral in pH (6.9) and are rich in planktonic organisms. The water is stagnant and abounds with colloids. The shore is 100% organic and the substrate of the entire bog is made up of peat. The

waters of the bog mat are acid (see Table 1).

Transeau (1906) considered putrefaction to be the chief process of reduction by which disintegration is carried on by anaerobic organisms and is favored by low temperatures, presence of acids, and low oxygen availability due to high water table. Products of putrefaction are of little use as nutrient materials for higher plants and nitrogen remains unavailable to plants.

METHODS

Field studies were made at Pennfield Bog from mid-April to mid-October, 1967. The bog was visited once each week during spring and fall and two collection and study trips a week were made during the summer months. Voucher specimens for all species reported from the bog are deposited in the Michigan State University Herbarium. Collections were also made of representative species in the major vegetation types surrounding the bog.

Quantitative data were collected during August to support recognition of the several vegetational societies. Two transects were run in the bog. The long axis ran at 16° west of magnetic north and was 660 meters in length. The shorter, perpendicular axis was 480.5 meters long. Because of the structural nature of the habitat two kinds of sampling procedures were employed. The herb and subshrub societies were sampled by quadrats one-half meter square. In

TABLE 1. Average pH values in Pennfield Bog.

Zone	pH value
Open water	6.9
Nuphar-Eleocharis	
Surface water	7.15
Submerged mat	6.25
Decodon	
Surface water	6.93
Submerged mat	6.5
Carex-Vaccinium macrocarpon	6.03
Depressions	6.8
Sphagnum hummocks	4.7
Cassandra	4.76
Larix	
Vaccinium corymbosum understory	4.5
Deep *Sphagnum* mat	4.18
Larix-Salix subzone	6.07
Acer rubrum	4.81
Openings at outer edge	6.42

the tree communities quadrats of the same size were used to examine the ground cover, while point intercepts were used to survey canopy and understory shrub and tree species (nearest species to quadrat recorded). One hundred quadrats were distributed (as determined by a table of random numbers) along each transect. Point intercepts recorded in the *Larix* and *Acer rubrum* zones were at the same locations as the quadrats.

In each quadrat the species and their approximate percent cover were recorded. Species with little significant cover were recorded as having 1% cover. Frequency, cover, and importance values were then tabulated for each vegetational zone. Determination of importance values follows the method of Beaman and Andresen (1966) which is a summation of percent total frequency and percent total cover data, thus giving a summation constant of 200.

A Beckman Pocket pH meter (model 180) was used to obtain pH values of surface soil and water in the major plant communities. The total of 53 readings was taken on August 31.

VEGETATION

The bog consists of seven major plant zones: a *Nuphar-Eleocharis* zone, a *Decodon* zone, a *Carex-Vaccinium macrocarpon* zone, a *Cassandra* zone, a *Cassandra-Thelypteris* zone, a *Larix* zone, and an outermost *Acer rubrum* zone. The bog community, undergoing the natural processes of succession, is slowly encroaching upon the open water of Goose and Little Goose Lakes. The general aspect of the bog can be seen in Figs. 2 and 3. Vegetational zones are shown in Fig. 1.

A number of species occur in nearby open water just off the bog mat and are floating or submerged aquatics. The most conspicuous species include *Ceratophyllum demersum, Myriophyllum verticillatum, Nymphaea tuberosa, Brasenia schreberi, Utricularia vulgaris, U. purpurea, Potamogeton illinoensis, P. natans,* and *P. gramineus.*

THE *NUPHAR-ELEOCHARIS* ZONE (TABLE 2)

The rhizomes and fibrous roots of *Eleocharis smallii* and the stout rhizomes of *Nuphar luteum* provide the major network for the submerged mat of this zone which is the forerunner of the quaking bog mat.

The dominant species, *Eleocharis smallii* and *Nuphar luteum,* are perennial, rhizomatous aquatics. Other important species which contribute to the structure of the substrate include *Pontederia cordata, Nymphaea tuberosa, Potentilla palustris,* and *Carex lasiocarpa.* A number of floating and submerged aquatic species are also present, but have little importance in terms of construction of the bog mat.

THE *DECODON* ZONE (TABLE 3)

Another pioneer zone is the *Decodon* mat which has developed on the west shores of Little Goose Lake and Goose Lake. Like the *Nuphar-Eleocharis* zone, the *Decodon* zone is characterized by a submerged mat. The surface water of the zone is nearly neutral while the submerged mat is slightly acid. The mat is

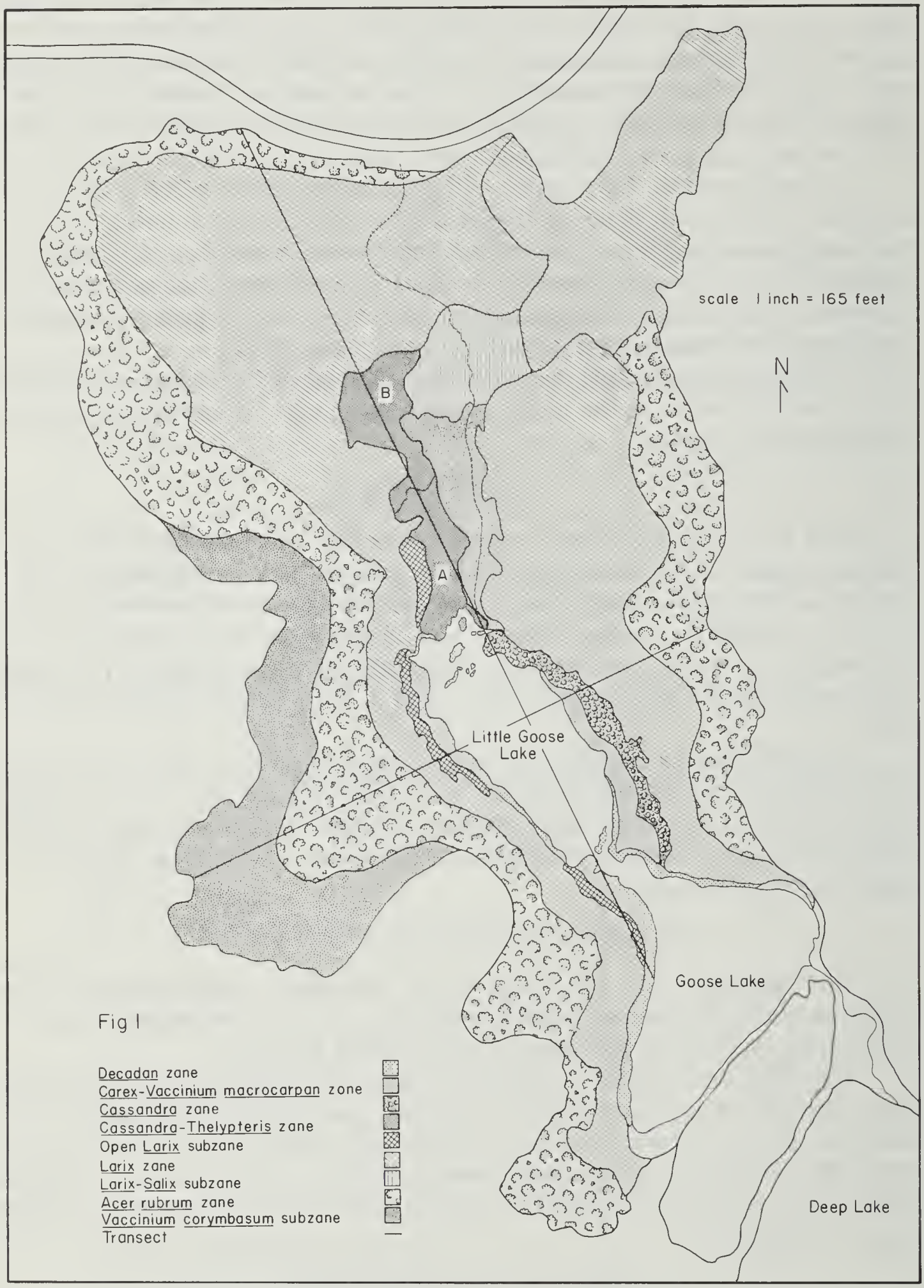

Fig. 1. Vegetation map of Pennfield Bog showing vegetation zones and subzones and transect locations. Adapted from an aerial photograph (BDF-5AA-102 by USDA Agricultural Stabilization and Conservation Service) enlarged with a Saltzman's projector.

Fig. 2. Oblique aerial view of Little Goose Lake encircled by bog mat (view looking northeast). October 22, 1967.

Fig. 3. *Decodon* mat encroaching upon Little Goose Lake (view looking northwest). July 22, 1967.

TABLE 2. Frequency, cover, and importance values of 21 species encountered in 19 quadrats in the *Nuphar-Eleocharis* zone.

Species	% Frequency	% Cover	Importance Value
Nuphar luteum	73.68	40.05	47.26
Eleocharis smallii	89.47	28.58	40.73
Potamogeton gramineus	63.15	11.79	21.79
Nymphaea tuberosa	42.10	16.32	21.55
Pontederia cordata	47.36	3.84	12.18
Utricularia vulgaris	36.84	6.31	12.24
Brasenia schreberi	21.05	2.16	5.79
Potentilla palustris	21.05	2.16	5.79
Potamogeton illinoensis	21.05	1.05	5.26
Carex lasiocarpa	10.52	2.37	3.95
Sparganium minimum	15.78	0.79	3.64
Sparganium chlorocarpum	15.78	0.68	3.55
Lemna minor	15.78	0.16	3.12
Decodon verticillatus	5.26	2.37	2.95
Dulichium arundinaceum	10.52	0.26	2.20
Sagittaria latifolia	10.52	0.16	2.12
Cassandra calyculata	5.26	0.53	1.43
Triadenum virginicum	5.26	0.21	1.16
Lemna trisulca	5.26	0.05	1.03
Sium suave	5.26	0.05	1.03
Utricularia purpurea	5.26	0.05	1.03

a quaking structure and will occasionally break under the weight of a person. *Decodon verticillatus* is the dominant species, comprising 23.58% of the total cover. Other important species include *Cassandra calyculata, Typha latifolia, Nuphar luteum, Eleocharis smallii,* and *Thelypteris palustris,* all of which are rhizomatous herbs except the shrubby *C. calyculata.*

The majority of plants are emergent aquatics. They give a hummock-like aspect to the mat where the dense growth—especially that of *Decodon verticillatus,* with its thickened, spongy stem base—collects some litter and provides a microhabitat for bryophytes and such angiosperms as *Drosera rotundifolia, Campanula aparinoides, Lycopus uniflorus,* and *Viola nephrophylla.*

Growth of the mat is enhanced by the ability of *Decodon verticillatus* to root freely at the tips when the arching branches touch the water.

THE *CAREX-VACCINIUM MACROCARPON* ZONE (TABLE 4)

The establishment of the floating mat requires a dense community of sedges around the lake margin. The rhizomes of the sedges grow out into the water behind the *Nuphar-Eleocharis* zone, forming an interlacing of roots and rhizomes, buoyed up by the water. As the mat encroaches upon the open water it loses contact with the bottom.

The sedge mat is dominated by three clonal species: *Carex lasiocarpa, Vaccinium macrocarpon,* and *Thelypteris palustris.* The table indicates that *Vaccinium macrocarpon* is the most important species of the zone, but if an

TABLE 3. Frequency, cover, and importance values of 25 species encountered in 9 quadrats in the *Decodon* zone.

Species	%% Frequency	% Cover	Importance Value
Decodon verticillatus	88.88	25.00	37.37
Cassandra calyculata	33.33	12.22	16.69
Brasenia schreberi	22.22	13.89	16.54
Typha latifolia	33.33	11.67	16.17
Nuphar luteum	22.22	11.11	13.92
Eleocharis smallii	44.44	6.11	12.65
Thelypteris palustris	44.44	5.67	12.23
Lycopus uniflorus	55.55	0.56	9.14
Osmunda regalis	11.11	6.67	8.01
Utricularia vulgaris	33.33	1.56	6.64
Spiraea tomentosa	22.22	3.11	6.37
Potentilla palustris	22.22	2.56	5.85
Sium suave	33.33	0.33	5.48
Triadenum virginicum	22.22	2.00	5.32
Sagittaria latifolia	22.22	1.56	4.91
Carex comosa	22.22	0.22	3.64
Sparganium minimum	22.22	0.22	3.64
Salix petiolaris	11.11	0.56	2.24
Dulichium arundinaceum	11.11	0.22	1.92
Pontederia cordata	11.11	0.22	1.92
Campanula aparinoides	11.11	0.11	1.82
Drosera rotundifolia	11.11	0.11	1.82
Epilobium strictum	11.11	0.11	1.82
Vaccinium macrocarpon	11.11	0.11	1.82
Viola nephrophylla	11.11	0.11	1.82

importance value could be determined from a summation of relative frequency, cover, and extensiveness of root system, *Carex lasiocarpa* would certainly be primary in importance, with *Vaccinium macrocarpon* the secondary species. The importance value of *Cassandra calyculata* is valid where the zone is relatively narrow, but at the north end of the bog where the development of the sedge mat is extensive, the species occurs almost exclusively where the sedge mat borders on the *Cassandra* zone.

The mat surface consists of small rises and pocket-like depressions. In early spring the mat is covered with water to a depth of approximately 30 cm. By mid-summer the water subsides, leaving only shallow pools in the depressions. *Sphagnum,* when it is present, occurs on the rises and the pH is an average 4.7 in these places. The pH is nearly neutral in the depressions, averaging 6.8, and the entire zone has an average pH of 6.03. During late summer the aerobic decay process is enhanced by higher temperatures, near-neutral pH, and lowered water table. Some decay is apparent in the wet depressions. Only two species, *Utricularia intermedia* and *Drosera intermedia,* were observed to inhabit these depressions, to which, in fact, they were restricted.

The greatest diversity of species apparently occurs in this zone, but most have very low importance values.

TABLE 4. Frequency, cover, and importance values of 32 species encountered in 18 quadrats and point intercepts in the *Carex-Vaccinium macrocarpon* zone.

Species	% Frequency	% Cover	Importance Value
Quadrats			
Vaccinium macrocarpon	88.88	47.22	43.64
Carex lasiocarpa	94.44	32.83	34.44
Thelypteris palustris	55.55	13.17	16.04
Cassandra calyculata	55.55	10.22	14.01
Triadenum virginicum	55.55	4.28	9.93
Potentilla palustris	38.88	3.94	8.83
Andromeda glaucophylla	22.22	4.44	5.84
Nuphar luteum	16.66	5.00	5.52
Sium suave	38.88	0.61	5.30
Typha latifolia	22.22	3.61	5.18
Lycopus uniflorus	33.33	1.22	5.02
Salix pedicellaris	27.77	1.39	4.44
Sagittaria latifolia	27.77	0.78	4.02
Sarracenia purpurea	22.22	1.11	3.55
Sphagnum spp.	11.11	2.83	3.33
Eleocharis smallii	11.11	2.50	3.10
Potamogeton gramineus	16.66	1.06	2.81
Onoclea sensibilis	16.66	0.39	2.35
Utricularia intermedia	16.66	0.39	2.35
Hypericum boreale	11.11	1.39	2.34
Carex comosa	11.11	1.22	2.22
Campanula aparinoides	16.66	0.17	2.20
Boehmeria cylindrica	11.11	1.11	2.15
Toxicodendron vernix	5.55	1.67	1.83
Spiraea tomentosa	11.11	0.72	1.81
Bidens coronata	11.11	0.55	1.76
Scutellaria galericulata	11.11	0.28	1.58
Drosera rotundifolia	11.11	0.11	1.46
Carex aquatilis	5.55	0.56	1.07
Drosera intermedia	5.55	0.28	0.88
Dulichium arundinaceum	5.55	0.06	0.73
Point intercepts			
Larix laricina	11.11		

TABLE 5. Frequency, cover, and importance values of 6 species encountered in 4 quadrats in the *Cassandra* zone on the east side of Little Goose Lake.

Species	% Frequency	% Cover	Importance Value
Sphagnum spp.	100.00	87.50	77.31
Cassandra calyculata	100.00	71.25	67.60
Vaccinium macrocarpon	75.00	5.25	21.88
Drosera rotundifolia	75.00	0.75	19.19
Typha latifolia	25.00	1.25	6.99
Sarracenia purpurea	25.00	1.25	6.99

THE *CASSANDRA* ZONE (TABLE 5)

The *Cassandra* zone succeeding the *Carex-Vaccinium macrocarpon* zone is characterized by a dense growth of this low shrub, with *Sphagnum* forming a cushion about the stems and branches. The substrate of the zone is very acid, having an average pH value of 4.7.

The portion of the zone on the east side of Little Goose Lake is representative of what might be considered a "typical" *Cassandra* zone. The zone is dominated by *C. calyculata* with a deep cushion of *Sphagnum* which grows up around the base of the shrubs. The number of species present is small.

THE *CASSANDRA-THELYPTERIS* ZONE (TABLE 6)

In the northern part of the bog the *Cassandra*-dominated zone takes on a quite different appearance. Although *C. calyculata* is the most important species in this very wet zone, *Thelypteris palustris* and *Typha latifolia* nearly equal it in importance; thus the zone is referred to as the *Cassandra-Thelypteris* zone. The zone has become a tension zone, being bordered on the south by the *Nuphar-Eleocharis* zone, on the west and north by the *Larix* zone, on the northeast by the *Larix-Salix* subzone, and on the east by the *Carex-Vaccinium macrocarpon* zone. Because of the very wet nature of the zone, *Sphagnum* has a much lower importance value in this portion of it, making up only 12.83% of the total cover.

This part of the bog is very diverse in number of species, and there are two distinct areas of subdivision. The column heading "Subzone A" in Table 6 refers to the area to the immediate north of Little Goose Lake (see Fig. 1). *Cassandra calyculata, Thelypteris palustris,* and *Typha latifolia* are still the dominant species, but *Sphagnum* is more prevalent in this area and makes up 24.08% of the total cover, second only to *C. calyculata.*

The area farther north along the transect is very wet and scattered clumps of *Larix* are numerous. The data for this area in Table 6 are headed "Subzone B." In this transitional area the dominant species are again *Cassandra calyculata, Thelypteris palustris,* and *Typha latifolia. Sphagnum,* however, is much less important, making up only 4.56% of the total cover. The clumps of *Larix* provide a niche for some species that would not otherwise be present in the zone, such as *Menyanthes trifoliata, Calla palustris, Cypripedium acaule, Maianthemum canadense, Carex aquatilis,* and *Rosa palustris.*

Data for both areas are totaled in a third column in Table 6. Although the frequency of *Larix* is nearly the same in both areas, the trees in subzone A are often single in occurrence while the trees mostly occur in clumps in subzone B. Fifty percent of the species in the zone are not duplicated in the two areas, and those of subzone B have affinities with the *Larix* zone and the *Larix-Salix* subzone.

THE *LARIX* ZONE (TABLES 7 & 8)

Larix forms a very extensive zone encircling the bog and dominates the stage of succession replacing the *Cassandra* zone. The zone can be divided into three subzones: the open *Larix* subzone, the *Larix-Salix* subzone, and the closed *Larix* bog forest.

TABLE 6. Frequency, cover, and importance values of 32 species encountered in 43 quadrats and point intercepts in the *Cassandra-Thelypteris* subzone A (15 quadrats) and subzone B (28 quadrats).

Species	% Frequency			% Cover			Importance Value		
	Subzone A	Subzone B	Total A + B	Subzone A	Subzone B	Total A + B	Subzone A	Subzone B	Total A + B
Quadrats									
Cassandra calyculata	66.66	75.00	72.09	45.00	38.10	40.51	42.83	49.63	47.08
Thelypteris palustris	80.00	75.00	76.74	20.87	20.57	20.67	29.06	33.65	31.79
Typha latifolia	66.66	67.85	67.44	23.06	14.28	17.53	28.04	26.50	27.42
Sphagnum spp.	60.00	25.00	37.20	35.73	5.00	15.72	35.33	9.48	20.06
Carex lasiocarpa	26.66	53.57	44.18	4.07	8.18	6.74	7.73	18.09	14.09
Potentilla palustris	26.66	32.14	30.23	3.67	4.96	4.74	7.46	10.90	9.73
Lycopus uniflorus	26.66	32.14	30.23	1.20	0.50	1.14	5.79	6.83	6.80
Cornus stolonifera	0.00	14.28	16.27	0.00	4.46	2.90	0.00	6.89	5.52
Potamogeton gramineus	20.00	14.28	16.27	1.13	0.43	0.67	4.51	3.22	3.70
Salix petiolaris	0.00	21.42	13.95	0.00	1.36	0.88	0.00	3.67	3.42
Triadenum virginicum	26.66	7.14	13.95	1.20	0.07	0.47	5.79	2.72	3.09
Scirpus cyperinus	0.00	3.57	2.32	0.00	0.54	0.35	0.00	1.19	2.93
Eupatorium purpureum	26.66	3.57	11.62	2.00	0.18	0.81	6.33	0.86	2.91
Bidens coronata	0.00	21.42	13.95	0.00	0.36	0.23	0.00	4.57	2.89
Toxicodendron vernix	13.33	3.57	6.97	2.20	1.43	1.58	3.97	2.00	2.63
Calla palustris	0.00	10.71	6.97	0.00	1.60	1.05	0.00	3.67	2.20
Spiraea alba	6.66	3.57	4.65	1.00	1.43	1.28	1.91	2.00	1.94
Vaccinium macrocarpon	0.00	7.14	4.65	0.00	1.89	1.23	0.00	3.13	1.90
Spiraea tomentosa	13.33	0.00	4.65	3.00	0.00	1.05	4.51	0.00	1.75
Scutellaria galericulata	6.66	7.14	6.97	0.13	0.32	0.26	1.32	1.70	1.56
Campanula aparinoides	13.33	3.57	6.97	0.27	0.07	0.14	2.67	0.76	1.46
Onoclea sensibilis	13.33	0.00	4.65	1.80	0.00	0.63	3.70	0.00	1.41
Sium suave	13.33	3.57	6.97	0.13	0.04	0.07	2.57	0.73	1.40
Salix pedicellaris	6.66	3.57	4.65	0.27	0.11	0.16	1.42	0.80	1.03
Carex aquatilis	0.00	3.57	2.32	0.00	0.89	0.58	0.00	1.51	0.92
Acer rubrum	6.66	0.00	2.32	0.67	0.00	0.23	1.69	0.00	0.64
Viola nephrophylla	6.66	0.00	2.32	0.53	0.00	0.19	1.59	0.00	0.60
Cypripedium acaule	0.00	3.57	2.32	0.00	0.25	0.16	0.00	0.92	0.58
Maianthemum canadense	0.00	3.57	2.32	0.00	0.25	0.16	0.00	0.92	0.58
Muhlenbergia racemosa	6.66	0.00	2.32	0.33	0.00	0.12	1.46	0.00	0.54
Drosera rotundifolia	6.66	0.00	2.32	0.07	0.00	0.02	1.28	0.00	0.46
Rosa palustris	0.00	3.57	0.36	0.00	2.32	0.23	0.00	2.81	0.25
Point intercepts									
Larix laricina	20.00	17.85	18.60						
Toxicodendron vernix	26.66	14.28	18.60						
Ilex verticillata	0.00	3.57	2.32						

TABLE 7. Frequency, cover, and importance values of 24 species encountered in 17 quadrats and point intercepts on the deep *Sphagnum* mat associated with the open *Larix* subzone of the west side.

Species	% Frequency	% Cover	Importance Value
Quadrats			
Sphagnum magellanicum	88.23	80.59	69.12
Thelypteris palustris	47.05	17.18	20.45
Vaccinium macrocarpon	58.82	8.65	17.40
Cassandra calyculata	47.05	9.52	14.11
Andromeda glaucophylla	29.41	8.53	11.37
Menyanthes trifoliata	23.52	4.76	9.25
Carex lasiocarpa	29.41	4.88	9.05
Osmunda regalis	11.76	6.76	6.68
Typha latifolia	17.64	3.57	6.37
Eriophorum virginicum	17.64	3.06	5.51
Carex interior	11.76	4.41	5.18
Pogonia ophioglossoides	17.64	0.29	3.75
Potentilla palustris	11.76	0.94	2.97
Vaccinium corymbosum	11.76	0.94	2.97
Acer rubrum	11.76	0.53	2.71
Campanula aparinoides	11.76	0.12	2.45
Sagittaria latifolia	5.88	0.47	1.48
Sarracenia purpurea	5.88	0.47	1.48
Salix petiolaris	5.88	0.24	1.34
Potamogeton gramineus	5.88	0.12	1.26
Triadenum virginicum	5.88	0.12	1.26
Lycopus uniflorus	5.88	0.06	1.22
Scutellaria galericulata	5.88	0.06	1.22
Trientalis borealis	5.88	0.06	1.22
Point intercepts			
Larix laricina	23.52		
Toxicodendron vernix	17.64		

The younger stages of the zone are characterized by an open bog forest. This has a general appearance somewhat suggestive of savanna, with the frequency of *Larix laricina* being 23.52% and *Toxicodendron vernix* occurring with a frequency of 17.64%. There is a deep, luxuriant mat of *Sphagnum magellanicum* carpeting the zone.

In Table 7, data are tabulated for the open portion of the *Larix* zone. The mat is acid, having an average pH value of 4.18. The most acid reading, pH 3.7, was taken on this *Sphagnum* mat.

The *Larix-Salix* subzone occurs in the northern part of the bog. Since neither transect passed through this area, no quantitative data were recorded. The subzone is, however, easily recognized. *Larix laricina* is the most conspicuous tree species and *Salix bebbiana* the most abundant shrub. The area is very wet and takes on the aspect of a young swamp forest with tall shrubs and small trees with hummocks formed at the base. The average pH is 6.07. A number of the species present are common in swampy habitats. These include *Cornus*

stolonifera, Betula pumila, Rosa palustris, Ribes americanum, R. hirtellum, Salix serissima, Bidens coronata, B. cernua, and *Scirpus acutus.*

A number of years ago a path was constructed by dragging logs through the *Larix-Salix* subzone to provide easy access for cranberry pickers. The path now consists of very loosely consolidated peat and is under water most of the

TABLE 8. Frequency, cover, and importance values of 28 species encountered in 36 quadrats and point intercepts in the mature *Larix* zone.

Species	% Frequency	% Cover	Importance Value
Quadrats			
Sphagnum spp.	72.22	39.67	81.58
Cassandra calyculata	16.66	7.36	16.16
Vaccinium corymbosum	27.77	4.91	16.04
Osmunda regalis	5.55	5.28	9.57
Acer rubrum	27.77	0.44	9.42
Carex interior	16.66	2.50	8.90
Maianthemum canadense	19.44	0.44	6.79
Trientalis borealis	16.66	0.50	6.00
Carex trisperma	16.66	0.17	5.51
Sarracenia purpurea	11.11	3.51	4.82
Ilex verticillata	8.33	0.83	3.85
Cypripedium acaule	11.11	0.22	3.83
Lycopus uniflorus	8.33	0.36	3.16
Thelypteris palustris	8.33	0.28	3.04
Rubus hispidus	8.33	0.08	2.74
Rosa palustris	2.77	1.11	2.51
Salix pedicillaris	2.77	1.11	2.51
Quercus velutina	5.55	0.17	2.00
Vaccinium macrocarpon	5.55	0.17	2.00
Carex aquatilis	2.77	0.56	1.69
Typha latifolia	2.77	0.14	1.07
Menyanthes trifoliata	2.77	0.06	0.95
Viola affinis	2.77	0.06	0.95
Woodwardia virginica	2.77	0.06	0.95
Drosera rotundifolia	2.77	0.03	0.91
Habenaria ciliaris	2.77	0.03	0.91
Monotropa uniflora	2.77	0.03	0.91
Rhynchospora alba	2.77	0.03	0.91
Point intercepts			
Vaccinium corymbosum	86.11		
Larix laricina	72.22		
Nemopanthus mucronata	13.88		
Acer rubrum	8.33		
Ilex verticillata	8.33		
Quercus velutina	5.55		
Toxicodendron vernix	5.55		
Nyssa sylvatica	2.77		
Salix petiolaris	2.77		
Ulmus rubra	2.77		

summer. By the end of the summer, when the water table is much lower, the path takes on a consistency of a very wet muck. A few plants were recorded from along this path and nowhere else in the bog. Among these are *Ranunculus sceleratus, Rumex orbiculatus, Scirpus acutus,* and *Boehmeria cylindrica* (shade form).

The mature *Larix* zone is a closed bog forest where *Larix laricina* has a frequency of 72.22%. It has a very dense understory with *Vaccinium corymbosum* being the dominant shrub. The data for the ground cover are given in Table 8. As the table indicates, there is very little ground cover. *Sphagnum* is by far the most frequent plant, but has a cover value of only 39.67%. The remaining species provide very little cover. Most of the species listed in Table 8 occur near the margin of the zone.

The zone is acid with an average pH value of 4.5.

THE *ACER RUBRUM* ZONE (TABLES 9 & 10)

The climax stage of the bog forest encircles the *Larix* zone and is dominated by *Acer rubrum,* which has a frequency of 65.78%. Other tree species are infrequent, as indicated by the low incidence of point intercepts. The frequencies of *Nyssa sylvatica* and *Pinus strobus* are inflated. *Nyssa sylvatica* was located in only two stations, both of which occurred on the transect line. Only two tall trees and two saplings of *Pinus strobus* were noted in the bog.

The understory is dominated by *Ilex verticillata* and *Vaccinium corymbosum.* Together the two species have a frequency of 73.68%. *Nemopanthus mucronata* is also frequent in the zone and should, perhaps, have a higher percent frequency than is indicated in Table 9. *Toxicodendron vernix* occurs in this zone also, but tends to frequent places where the shade is light.

The *Acer rubrum* zone has a much denser ground cover than the *Larix* zone. The predominant species of *Sphagnum* is *S. fimbriatum,* which forms clumps rather than a deep, continuous cushion as does *S. magellanicum* in the *Larix* zone. *Maianthemum canadense* is the most frequent herb and *Ilex verticillata* is the most frequent woody seedling. *Osmunda cinnamomea* is also an important species of the zone and is abundant in very wet places.

Along the outer margin of the bog there are numerous openings in the *Acer rubrum* zone. The species present in these openings tend to be typical of swampy sites. These include such species as *Viburnum lentago, Cornus stolonifera, Corylus americana, Echinocystis lobata, Vitis vulpina, Leersia oryzoides, Glyceria striata, Aster umbellatus, Urtica dioica, Bidens cernua, B. coronata, Impatiens biflora,* and *Alisma plantago-aquatica.* The pH of these openings averages 6.42 while the pH of the *Acer rubrum* zone averages 4.81.

On the west side of Little Goose Lake there is a large *Vaccinium corymbosum* subzone associated with the *Acer rubrum* zone. *Vaccinium corymbosum,* with a 100% frequency value, forms a very dense thicket. *Aronia melanocarpa* is also frequent, occurring at one-third of the point intercepts. *Acer rubrum* occurs with a frequency of 22.72% and the trees are mostly very large and quite scattered. They cast very little shade on the area. There are very few groundcover species and these provide very little cover. *Sphagnum* attains its highest

TABLE 9. Frequency, cover and importance values of 23 species encountered in 38 quadrats and point intercepts in the *Acer rubrum* zone.

Species	% Frequency	% Cover	Importance Value
Quadrats			
Sphagnum spp.	42.10	13.95	53.07
Maianthemum canadense	85.71	5.60	40.84
Ilex verticillata	85.71	3.87	35.72
Osmunda cinnamomea	15.78	5.24	19.97
Trientalis borealis	28.94	1.50	12.62
Lycopus uniflorus	26.31	0.47	8.84
Rubus hispidus	18.42	0.58	6.92
Vaccinium corymbosum	7.89	0.92	4.94
Acer rubrum	5.26	0.71	3.59
Thelypteris palustris	7.89	0.18	2.76
Carex trisperma	7.89	0.08	2.46
Galium trifidum	5.26	1.49	1.63
Woodwardia virginica	2.63	0.18	1.27
Cypripedium acaule	2.63	0.13	1.12
Rosa palustris	2.63	0.13	1.12
Toxicodendron vernix	2.63	0.13	1.12
Quercus velutina	2.63	0.05	0.88
Mitchella repens	2.63	0.03	0.82
Point intercepts			
Acer rubrum	65.78		
Ilex verticillata	39.47		
Vaccinium corymbosum	34.21		
Nemopanthus mucronata	7.89		
Nyssa sylvatica	5.26		
Pinus strobus	5.26		
Aronia melanocarpa	2.63		
Betula lutea	2.63		
Quercus velutina	2.63		
Toxicodendron vernix	2.63		

importance value here since it has high frequency and cover values and since few other species contribute to the ground cover. It is interesting to note that no *Acer rubrum* seedlings were encountered in the quadrats. Data for this subzone are given in Table 10.

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This paper represents the first portion of a thesis submitted to Michigan State University in partial fulfillment of the requirements for the degree of Master of Science; a phytogeographic analysis will follow.

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TABLE 10. Frequency, cover, and importance values of 10 species encountered in 22 quadrats and point intercepts in the *Vaccinium corymbosum* subzone associated with the *Acer rubrum* zone on the west side.

Species	% Frequency	% Cover	Importance Value
Quadrats			
Sphagnum spp.	77.27	52.73	116.51
Rubus hispidus	31.81	14.89	19.38
Maianthemum canadense	36.36	1.45	19.22
Vaccinium corymbosum	18.18	4.77	15.77
Trientalis borealis	22.72	0.32	11.11
Osmunda cinnamomea	18.63	2.82	10.67
Aronia melanocarpa	13.63	0.59	7.27
Point intercepts			
Vaccinium corymbosum	100.00		
Aronia melanocarpa	36.36		
Acer rubrum	22.72		
Toxicodendron vernix	9.09		
Amelanchier arborea	4.54		

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BRYOPHYTES NEW TO MICHIGAN. II[1]

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A continuation of bryological activity in various parts of Michigan during the past year has resulted in a number of interesting additions to the state flora. In addition to the four taxa reported here, 14 species new to the state, to be reported by others but named or confirmed by us, might be given cursory mention in the interest of unifying records: *Lophozia muelleri* (Nees) Dum. (Delta Co.), *Sphagnum annulatum* var. *porosum* (Schlieph. & Warnst. *ex* Warnst.) Maass & Isov. *ex* Maass (Cheboygan and Dickinson cos.), *S. auriculatum* Schimp. (Antrim and Chippewa cos.), *S. contortum* Schultz (Emmet, Houghton, and Mackinac cos.), *S. platyphyllum* (Lindb. *ex* Braithw.) Sull. *ex* Warnst. (Chippewa, Cheboygan, Kalkaska, Keweenaw, and Schoolcraft cos.), *S. pulchrum* (Lindb. *ex* Braithw.) Warnst. (Chippewa, Mackinac, and Schoolcraft cos.), *S. riparium* Ångstr. (Emmet and Luce cos.), *S. subfulvum* Sjørs (Chippewa and Luce cos.), *S. subnitens* Russ. & Warnst. *ex* Warnst. (Mackinac Co.), *Fissidens exilis* Hedw. (Eaton Co.), *Eucladium verticillatum* (Brid.) BSG (Delta Co.), *Physcomitrella patens* (Hedw.) BSG (Wayne Co.), *Sematophyllum demissum* (Wils.) Mitt. (Eaton Co.), and *Schwetschkeopsis fabronia* (Schwaegr.) Broth. (Berrien Co.).

Specimens cited below are deposited in the herbaria of the University of Michigan (MICH), Michigan State University (MSC), University of Michigan Biological Station (UMBS), or the private collection of Norton G. Miller. Unless otherwise stated, the distributional ranges given are those which we have confirmed by actual study of specimens.

Pottia davalliana (Sm. *ex* Drake) C. Jens. Bay Co. On soil in second-year clover field, Eight Mile Rd. 0.3 mi. N. of Cottage Grove Rd., Kawkawlin Township, *H. Crum,* Oct. 26, 1968 (MICH). Emmet Co. On dry, sandy loam in fallow field, 1.4 mi. N. of Brutus, *N. G. Miller 5005* in part, with *Pleuridium subulatum,* Aug. 16, 1968 (*in herb.* Miller). Genesee Co. On soil, mowed area at roadside 3 mi. W of Clio on M57, *H. Crum,* Oct. 26, 1968 (MICH). Presque Isle Co. On calcareous soil in bare spots of alfalfa field, 2.5 mi. E. of Posen, *N. G. Miller 4875,* Aug. 3, 1968 (MICH), also *Erica M. Frank,* Aug. 3, 1968 (MICH); on bare, calcareous soil, 1 mi. W. of M65 on Metz Rd. near Posen, *H. Crum,* Oct. 25, 1968 (MICH); on calcareous soil in mowed area, new section of Catholic cemetery, Posen, *H. Crum,* Oct. 25, 1968 (MICH). Saginaw Co. On soil in mowed

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area, outskirts of Zilwaukee, *H. Crum,* Oct. 26, 1968 (MICH). – A minute moss of rare occurrence on limey soils in disturbed places, such as old fields, pastures, lawns, and roadsides; southern Ontario; throughout Europe.

Ephemerum crassinervium (Schwaegr.) Hampe. Emmet Co. On sandy loam, moist depression in fallow field, 1.4 mi. N. of Brutus, *N. G. Miller* 5004, Aug. 16, 1968 (*in herb.* Miller; MICH), also *H. Crum,* Aug. 16, 1968 (MICH). Jackson Co. On soil in corn field, on Mt. Hope Rd. near creek ca. 0.8 mi. N. of Seymour Rd., *H. Crum, D. H. Vitt, W. W. Patrick, & Paula Collier,* Oct. 9, 1968 (MICH). Presque Isle Co. On soil at edge of stubble field, 1 mi. W. of Posen on Grand Lake Rd., *H. Crum,* Oct. 25, 1968 (MICH). Saginaw Co. On soil at edge of corn field, Birch Run, *H. Crum,* Oct. 24, 1968 (MICH). Washtenaw Co. On soil, cornfield, 0.7 mi. N. of Joy Rd. on Webster Church Rd., Webster Township, *H. Crum,* Oct. 17, 1968 (MICH); on soil, cornfield, on Walsh Rd. 0.6 mi. E. of Scully Rd., Webster Township, *H. Crum,* Oct. 17, 1968 (MICH). – A rare, ephemeral "pygmy" moss growing as scattered, minute buds on an abundant protonema, on damp soil in old fields, on river banks, along paths, or at roadsides. The species in endemic to North America where it ranges from Quebec and Ontario southward to Florida and Louisiana.

Pohlia annotina (Hedw.) Lindb. var. *annotina.* Alger Co. On wet sand, seepy roadside bank, with *Dicranella cerviculata,* NW. of Chapel Falls, ca. 7 mi. W. of Van Meer, *N. G. Miller 4999, D. H. Vitt 1160,* Aug. 13, 1968 (UMBS). – A moss best recognized by its dull appearance and regular production of small, yellowish, ovoid brood-bodies in leaf axils. The var. *loeskei* Crum, Steere, & Anders., which has elongate, somewhat twisted, vermicular brood-bodies, has also been found in a few Michigan localities (Bryologist 70: 118, 1967). The typical variety has been found in northern and central Europe, British Columbia to California, and a few localities in eastern North America (Michigan, New Hampshire, New York, and Ontario).

Campylium radicale (P.-Beauv.) Grout. Cheboygan Co. On moist humus and muck, bog forest, Livingston Bog, 2.5 mi. SE. of University of Michigan Biological Station, Burt Township, *N. G. Miller 3186,* June 30, 1966 (MICH). Ontonagon Co. Porcupine Mts., *G. E. Nichols & W. C. Steere,* Aug. 1935 (MICH, as *Amblystegium juratzkanum*). – A seldom recognized species resembling somewhat *C. polygamum* (BSG) C. Jens. but differing in smaller size and shorter leaf cells which are not or only slightly inflated at the basal angles. It may be recognized also by its remote, wide-spreading leaves which are abruptly narrowed to a channeled acumen from an ovate base. Only a few specimens have been seen, from Florida, Michigan, New Jersey, Pennsylvania, and Virginia; it has also been reported, by various authors, from Newfoundland and Maine.

Nature education feature --

NATURAL AREA PRESERVATION IN THE AGE OF THE MEGALOPOLIS[1]

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We live in an era in which the most obvious relationship of man to nature is disturbance and destruction. Bulldozing of hills, damming of streams, levelling of forests, spraying of roadsides, fields, timberlands—these are the hallmarks of an advanced technology and vigorous economy. These evidences of man's prowess as a *manipulator of nature* fill the daily press, second in precedence only to the news of political and social issues.

But the dedication of a tract of land as a *natural area* marks a different kind of relationship of man to the natural world. When we set aside an area to remain undisturbed, allowing native species of plants and animals to survive and maintain their natural ecological relationships, we underscore the urgency that man became a *respector and protector of nature.* The dedication of each natural area in Michigan, whether large or small, is therefore an important event worthy of public attention.

Some might question the importance of establishing natural area preserves, nature study areas, or wilderness tracts. In a world of burgeoning population growth and a finite supply of resources, should not all areas be exploited to yield their maximal production? Of what value are the vanishing species—those which may soon be added to the long list of extinctions caused by man? Of what consequence are the nature preserves with their confusing array of organisms and perplexing complex ecological processes? These questions press conservationists continually; they are especially insistent if short-term economic gain is an alternative to preservation. Develop the undeveloped; stretch the subdivision; provide more resorts; increase the tax base—these are the demands heard throughout Michigan and the entire country. Even the choicest areas, dedicated as state and national parks by early visionaries, are being threatened. Too frequently "inexpensive" rights-of-way are granted across public land; mineral, water, and timber rights are sought on these public lands, usually under the guise of saving the taxpayer money.

In the face of such economic pressures, let us now reassert that nature preservation is an important, even critical, state and national goal. The reasons are many, and mostly very practical; let me cite a few:

1. *Nature Study Areas* provide "living museums" or outdoor classrooms which allow observation and study of the world of nature in its unmanipulated, nearly

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[1]Remarks by the Chairman of the Michigan Natural Areas Council, delivered on the occasion of the dedication of the Nature Study Area at Fernwood, 1720 Range Line Road, Niles, Michigan, on October 6, 1968.

natural state. Students of all ages, those engaged in formal schooling or scouting, family groups, the casual adult, or the nature enthusiast, may observe firsthand the native plants, birds, mammals, and invertebrates. Frequently, as at Fernwood and some of our other outdoor nature centers, interpretive nature trails and displays supplement the direct observation of nature. No indoor classroom can provide such educational opportunities.

2. *Scenic Sites* in Michigan provide some of the most exquisite scenery in the world. Unless dedicated and preserved, they are liable to despoiling by buildings or other "human improvements" or they may fall into private ownership and their enjoyment be denied to the public.

3. *Managed Tracts* are natural areas dedicated to the preservation of interesting and rare species or communities and which require artificial management for their maintenance. In these instances, human management is encouraged, after appropriate ecological study, to promote preservation. Frequently this may require control of water level or periodic burning to maintain an area in an early stage of ecologic succession. The extinction of these species or demise of these unique ecological communities would be an irreparable loss; a loss significant even to *Homo sapiens,* the super-dominant species. For who can tell when we may need to turn to some of these native species for germ plasm for developing new species and varieties of economic importance? Who can assay the economic value of rich and diversified natural communities to effective tourism? Who can safely minimize the importance of natural areas as a setting for therapy to cure mental illness? Who will assert that humankind will be more humane and spiritually richer after he has despoiled, destroyed, or exterminated?

4. *Natural Area Preserves* contain one or more typical or unusual examples of plant and animal communities; they are dedicated for *maximum preservation* and for *scientific observation* and study of the biota. In some cases, these include substantial tracts of wilderness where man is but an occasional visitor. Preservation of such areas in their pristine state requires limitation of the number of visitors to those engaged in the serious study of nature. The traffic of thousands of human visitors would soon trample and destroy the very features to be protected. A very practical reason for the preservation is the provision of areas for scientific research. Aldo Leopold has said (*A Sand County Almanac,* 1949):

> The science of land-health (i.e. conservation), needs, first of all, a base datum of normality of how healthy land maintains itself as an organism.
>
> . . . Wilderness, then, assumes unexpected importance as a land laboratory.
>
> . . . each biotic province needs its own wilderness for comparative studies of used and unused land. It is of course too late to salvage more than a lop-sided system of wilderness remnants, and most of these are far too small to retain their normalcy. All wilderness areas, no matter how small or imperfect, have a large value to land science. The important thing is to remember that recreation is not their only, or even their principle, utility.

At the present time the need for such areas is being felt keenly by scientists participating in the International Biological Program. Ecologists studying productivity and pollution need undisturbed areas representative of all of the major

biomes of the world (e.g., prairie, deciduous forests, coniferous forests, etc.) to serve as controls in experimental ecological study. We cannot afford to lose another acre of wilderness for practical as well as aesthetic reasons!

ACTIVITIES OF THE MICHIGAN NATURAL AREAS COUNCIL

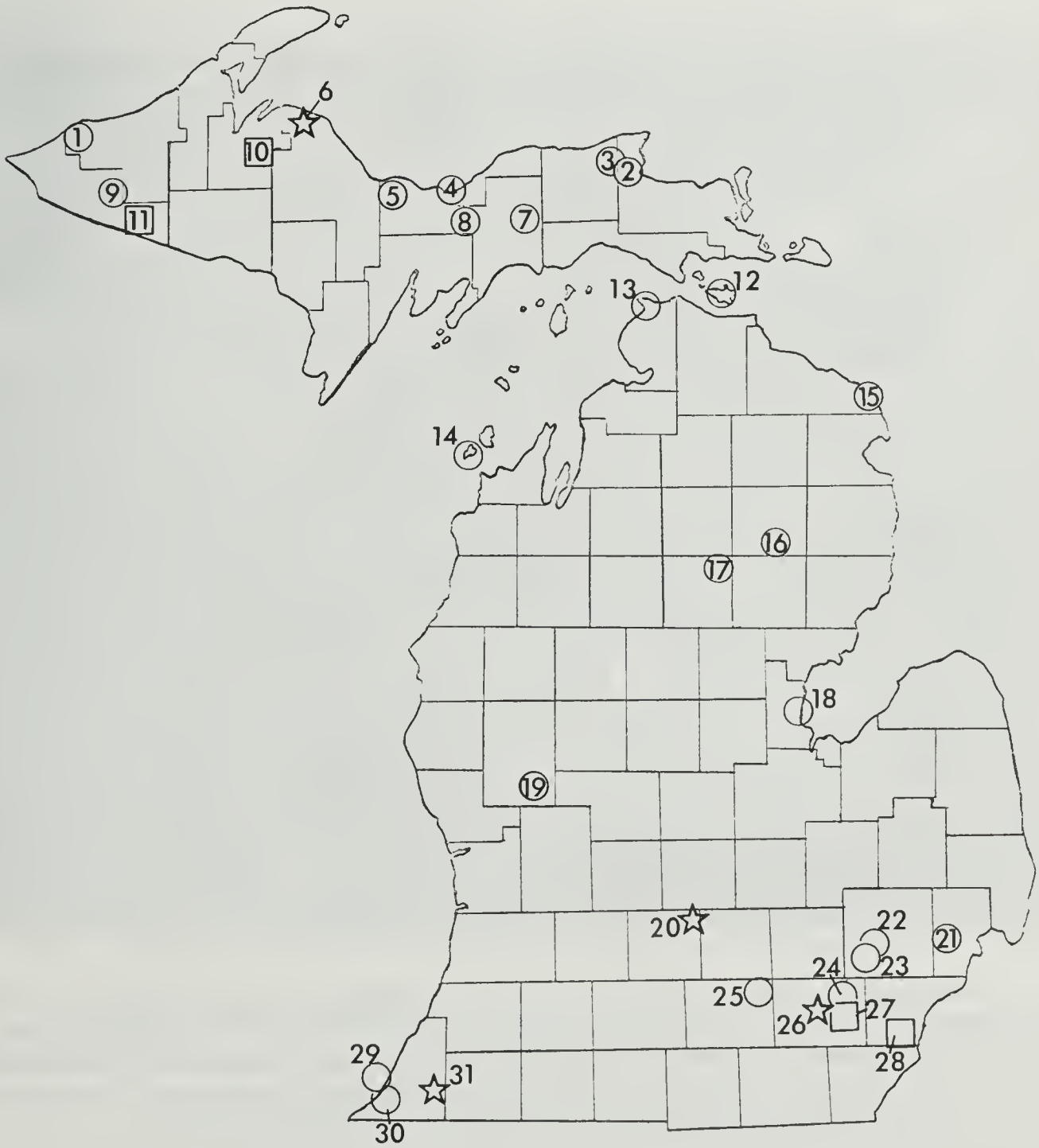
Since its independent organization in 1952, after several years as a committee of the Michigan Botanical Club, the Michigan Natural Areas Council has been instrumental in locating, evaluating and dedicating more than thirty natural areas in Michigan. As the Michigan representative of the Nature Conservancy, the Council pioneered in the development of preservation categories and has defined use patterns and safeguards suitable to each. Nature Study Areas, Scenic Sites, Managed Tracts, and Natural Area Perserves require different standards for pres-

Fig. 1. Natural Areas in Michigan: Circles represent dedicated areas in public ownership; stars represent private areas; squares represent some of the tracts now under study which should eventually be dedicated. Most of the dedications indicated here were accomplished with cooperation of the Michigan Natural Areas Council or the Michigan Botanical Club; the several sanctuaries of the Michigan Audubon Society and those dedicated by the Eastern Michigan Nature Association are not shown. The general location or name of area, acreage, and ownership are indicated below. Key: MDNR = Michigan Department of Natural Resources (formerly, Michigan Department of Conservation); USFS = United States Forest Service; NWR = National Wildlife Refuge; P = private.

1. Porcupine Mountains State Park, 45,210, MDNR
2. Tahquamenon Falls State Park, 4,868, MDNR
3. Betsy Lake area, 14,137, MDNR
4. Wagner Falls Scenic Site, 10, MDNR
5. Laughing Whitefish Falls Scenic Site, 160, MDNR
6. Huron Mountain Club, 17,700, P
7. Strangmoor, Seney Wildlife Refuge, 640, NWR
8. Northern hardwoods, Hiawaths National Forest, 200, USFS
9. Virgin cedar swamp, Ottawa National Forest, 233, USFS
10. Craig–Crooked Lake State Park project, MDNR
11. Sylvania, USFS
12. Bois Blanc Island, 696, MDNR
13. Wilderness State Park, 2,390, MDNR
14. South Manitou Island, 1,589, MDNR
15. Besser Natural Area, 135, MDNR
16. Kirtland's Warbler Management Area, 4,010, USFS
17. Roscommon virgin red pine stand, 160, MDNR
18. Tobico marsh, 1,652, MDNR
19. Newaygo prairie, Manistee National Forest, 80, USFS
20. Woldumar, about 80, P
21. Shadbush tract, Utica Recreation Area, 70, MDNR
22. Haven Hill, Highland Recreation Area, 806, MDNR
23. Proud Lake bog, 105, MDNR
24. Horner Woods, 44, University of Michigan Botanical Gardens
25. Black Spruce bog, Waterloo Recreation Area, 40, MDNR
26. Ann Arbor Outdoor Center, P
27. Ann Arbor wet prairie
28. Middlebelt prairie
29. Warren Dues State Park, 320, MDNR
30. Warren Woods, 312, MDNR
31. Fernwood, 18, P

ervation. In all of these, however, there are two common denominators for preservation: maintenance in indefinite perpetuity and minimal alteration or disturbance.

The Michigan Natural Areas Council does not own property. It identifies appropriate sites, and arranges for their dedication and preservation under auspices of an appropriate permanent owner. Most of the dedicated natural areas are in public ownership. The Council seeks to assure the zoning of state parks so that recreation and natural area preservation are maintained in appropriate balance. About 20% of the lands owned and managed by the Michigan Department of Natural Resources' Parks Division have been dedicated in a suitable category. The Council also cooperates with administrators of State and National Forests in selecting areas for preservation, recreation, and production. These natural areas in public ownership range in size from 45,000 acres in the Porcupine Mountains State Park and nearly 19,000 acres in the Tahquamenon Falls and Betsy Lake area, to an 80 acre relic-prairie Managed Tract in Newaygo County and a 10 acre



Scenic Site at Wagner Falls in Alger County (Fig. 1). In recent years private organizations, corporations, and individuals have also become interested in natural area preservation. The Huron Mountain Club pioneered in this effort by dedicating 17,700 acres in Marquette County. The Michigan Audubon Society has established sanctuaries, often in connection with nature centers; the Michigan Botanical Club has purchased plant sanctuaries for transfer to suitable managing agencies; the Eastern Michigan Nature Association has purchased several tracts. Private corporations have established nature centers and nature study areas; Woldumar, southwest of Lansing, and Fernwood, which we dedicate today, are examples (Fig. 1). In addition, many universities and colleges have ecological tracts which may or may not be under dedication.

Calculation of the total acreage preserved by these organizations is difficult. I believe, however, that the dedication of Fernwood Nature Study Area is a particularly auspicious occasion because it pushes that total over the 100,000-acre mark in Michigan.

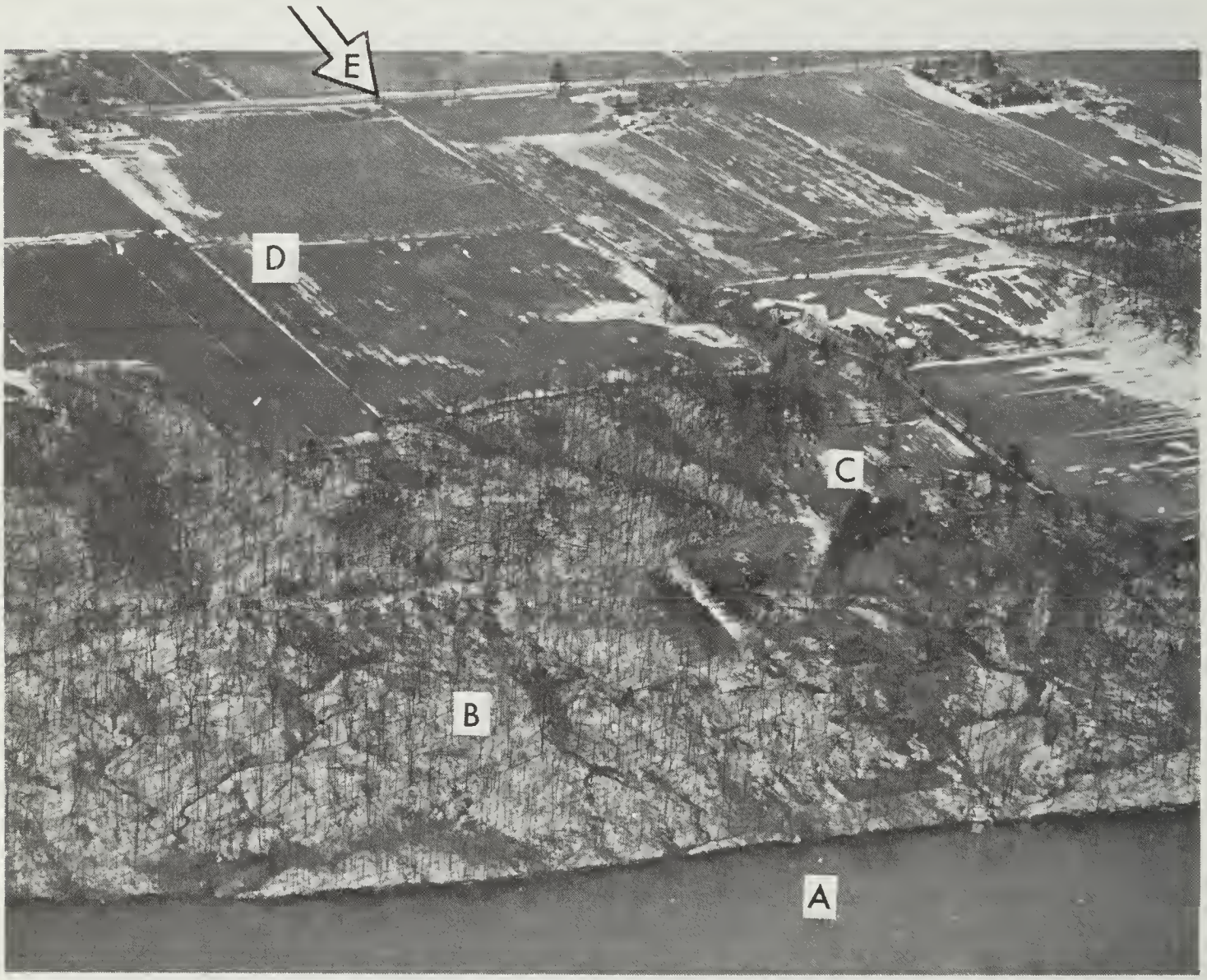


Fig. 2. Fernwood and adjacent lands, Berrien Co., Michigan. A: St. Joseph River; B: Nature Study Area, about 18 acres of woodland dedicated October 6, 1968; C: Nature Center area and gardens; D: Future arboretum and nursery area; E: Entrance gate at 1720 Range Line Road, the extreme southeast corner of the property. The road forms the east boundary and the river the west margin. (Photo by Roger E. Lorensen, March 31, 1965)

FERNWOOD NATURE STUDY AREA

The tract of land we dedicate today, as a Nature Study Area at Fernwood, is rich in plant species. In spite of its limited area, the ecologic diversity of the tract also provides nesting sites for many kinds of birds.

The area provides an important addition to the biotic communities which have been preserved in Michigan. At Warren Dunes and Warren Woods, which are also in Berrien County, a dunes community, deciduous hardwoods, and rich mesophytic beech-maple forest have been dedicated earlier as natural areas. Now this Fernwood tract adds a mosaic of river border habitats (Fig. 2). These three areas provide a fine nucleus of nature preserves for southwestern Michigan. If as many outstanding sites could be identified and dedicated in every county, the state would have an admirable and more nearly adequate system of natural areas.

In vast expanses of the state, particularly in the south-central, central, and northern Lower Peninsula, there are no dedicated natural areas. It might occur to someone that prior dedication of 100,000 acres is ample. However, 80% of this acreage is concentrated in five large tracts in the Upper Peninsula; southern Michigan has inadequate coverage and the dedicated areas are small. Those of us who are committed to the cause of nature education might take as a challenge, and an attainable goal, the establishment of natural area reserves in every county of the state.

Demographers predict the development of three huge strip cities in America by the year 2000. These will be Boswash on the east coast, and Sansan on the west, and Chipitts, into which Fernwood will fall. We can already see the developing urban sprawl from Chicago to Detroit, Cleveland, and Pittsburgh. It is most urgent that our work proceed quickly in this belt of high population density in southern Lower Michigan. Nature Study Areas and Nature Centers like Fernwood will serve increasing numbers of school children, college students, and researchers; the general public will be increasingly anxious to see, hear, and sense nature at its best.

SAMUEL H. WATSON, PIONEER BOTANIST OF SOUTHERN WISCONSIN

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In a previous note (Musselman, 1968) the collection of S. H. Watson in the Milton College herbarium was briefly mentioned. Further investigation has provided some information on the life and collection of this early botanist.

Samuel Harding Watson was born in Mildenhall, England, on December 1, 1837, and came to this country with his parents in 1847 when they settled on a

farm in Dunkirk Township in the southeast part of Dane County, Wisconsin. Watson entered the University of Wisconsin about 1858 and was most active from 1858 to 1861, collecting during the school year in Madison and in the vicinity of his parents' farm during the summer.

After leaving the university, Watson taught school near Waunakee and Okee, Wisconsin. In 1876 he began law practice in the office of Richard Lindsay in Lodi. According to his obituary in the Lodi *Enterprise,* Watson took an active part in community affairs and retained his interest in natural history until his death, caused by complications following pneumonia. He died at the home of his daughter in Waunakee on December 12, 1928, at the age of 91.

Watson's interest in botany may be traced to 1854 when at the age of 17 he prepared a list of 303 species entitled "Alphabetical index of plants sent to the University of Wisconsin," dated February, 1854. These specimens were undoubtedly destroyed in the fire which later burned the entire Wisconsin herbarium (Bryan, 1950).

Based on information gleaned from his labels, Watson took botany in 1859 at the University of Wisconsin, a course then taught by Dr. Ezra Carr (Bryan, 1950). Mr. T. J. Hale apparently was a student in the same class. Unlike his lesser known classmate, Hale published two papers on the Wisconsin flora, in which he made several references to Watson's collections (Musselman, 1968).

Many of the specimens from other collectors found in the Watson collection may have been obtained by Hale and passed on to Watson. A portion of Watson's collection is contained in nine 10″ x 12″ volumes along with many specimens obtained by Hale from other botanists. It is unclear as to how Watson's collections came to Milton but college records indicate that two of his younger brothers attended Milton College. Watson's collection has been undisturbed for nearly a century except for some mounting of specimens done around the turn of the century and some annotations by Albert Rogers Crandall ("ARC"), professor of natural history and physiology at Milton from 1902 to 1918.

Mr. Watson was an avid collector of all plants both cultivated and native. His collection contains such difficult groups as grasses, sedges, and cryptogams. Most of his collections were made in the Madison vicinity and in Dunkirk Township with only an occasional specimen from other localities. I have never encountered any Watson collections from outside Wisconsin although Pennell (1935) lists Michigan as one of the states in which he collected. Below is a listing of localities in which he collected:

COLLECTION SITES OF S. H. WATSON IN SOUTHERN WISCONSIN

"Janesville" (T3N, R12E, Rock Co.)

"Fulton" (Section 18, Fulton Township, T4N, R12E, Rock Co.)

"Porter" (Porter Township, T4N, R11E, Rock Co.)

"Union" (Section 10, Union Township, T4N, R10E, Rock Co.)

"Dunkirk," "D-" (Dunkirk Township, T5N, R11E, Dane Co.)

"Rutland" (Rutland Township, T5N, R10E, Dane Co.)

"Madison," "Mad." (T7N, R9E, Dane Co. Many collections were made on or near the university campus or lakes.)

"Pine Bluff" (Section 27, Cross Plains Township, T7N, R7E, Dane Co.)

"Mazo-manie" (Mazomanie Township, T9N, R8E, Dane Co.)

"Middleton" (Middleton Township, T7N, R8E, Dane Co.)

"Blue Mounds" (Section 11, Brigham Township, T6N, R5E, Iowa Co.)

"Arena" (Arena Township, T8N, R5E, Iowa Co. Many specimens labeled "Arena" are from the sand areas along the Wisconsin River.)

"Bluffs of the Wisconsin River, Sauk Co."

"Fort Atkinson" (T5N, R14E, Jefferson Co.)

"2nd Lake," "Dead Lake" (Perhaps in reference to some of the Madison lakes?)

Unfortunately many of Watson's labels contain little data other than the name of the plant. Figure 1 illustrates a representative label. Watson's collection is extremely valuable as an indication of the vegetation of southern Wisconsin as it existed over one hundred years ago. Of particular interest are his collections of prairie species which are now rare or uncommon, such as *Gerardia auriculata, Agoseris cuspidata,* and many others.

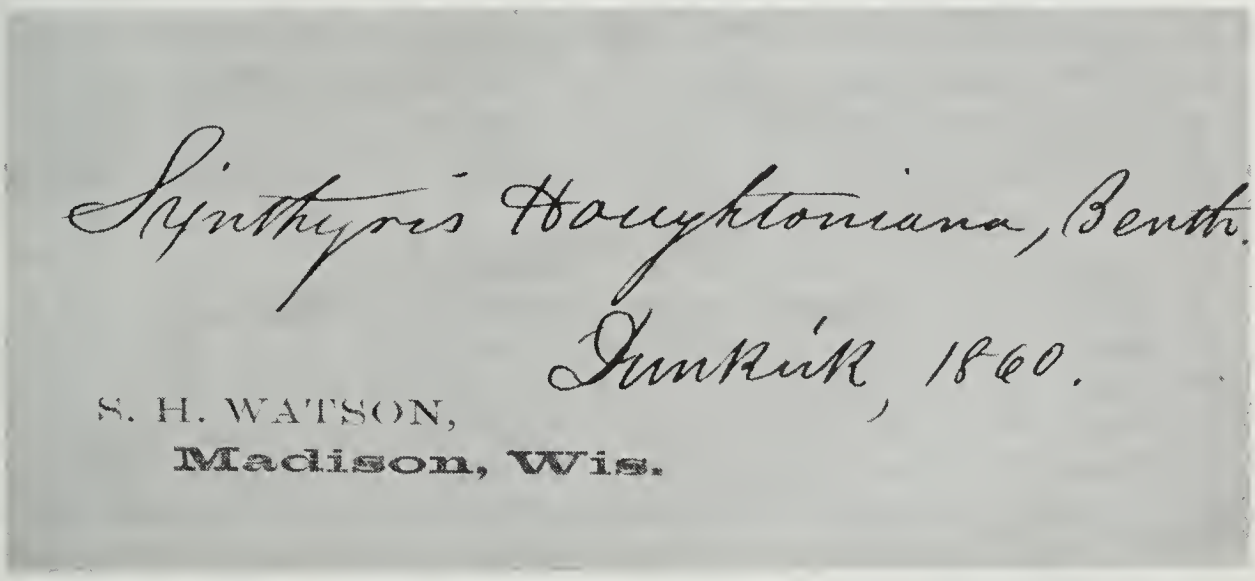

Fig. 1. Representative label of S. H. Watson.

ACKNOWLEDGMENTS

I wish to thank Mr. J. L. Skaggs (Registrar of Milton College), Mrs. Ruby Murphy (granddaughter of S. H. Watson), Dr. E. G. Voss, The Lodi *Enterprise,* and the Wisconsin State Historical Society for valuable assistance. Much help in the preparation of this paper was obtained from Dr. R. L. Stuckey's studies of early botanists. Portions of this work completed during the summer of 1968 were incidental to research supported by a University of Wisconsin Center System Research Grant.

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DARK-BARKED BIRCHES OF SOUTHERN MICHIGAN

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Yellow birch (*Betula alleghaniensis* Britton) is a highly variable member of the dark-barked birch group (subsection *Costatae* Regel) in the Great Lakes, St. Lawrence River, and Appalachian Mountain regions of North America. Originally named *B. lutea* Michaux fil., yellow birch is now called *B. alleghaniensis* because Michaux's name has been interpreted as illegitimate (Little, 1953; Brayshaw, 1966). Over much of its range, yellow birch may be quickly and easily identified by its characteristically yellowish, generously exfoliating bark and very pubescent and ciliate, palm-like pistillate bracts. Likewise, its relative of the Appalachian Mountains, the black, sweet, or cherry birch (*B. lenta* L.) is distinctive because of its dark reddish or black, cherry-like, nonexfoliating bark; and glabrous, somewhat cruciform, pistillate bracts. Upon discovering several dark and tight-barked birches in southeastern Michigan (Dancik, 1967), I initiated a search for past reports and interpretations of this taxon.

At various places in the range of yellow birch, particularly in southern Michigan, Minnesota, and Wisconsin, and northern Indiana and Ohio, a dark and tight-barked birch has been recognized. It has been called *B. lenta* L., *B. lutea* forma *fallax* Fassett (*B. alleghaniensis* var. *fallax* Brayshaw), and *B. alleghaniensis* Britton. Blanchard (1911) published one of the earliest accounts of this taxon and probably put it into the proper perspective at that time:

> The provincial botanists, having never seen the real black birch think that when they find a yellow birch (*B. lutea* L.) with black bark they have found a black birch, and lumbermen everywhere from the Adirondacks to New Brunswick are sure that they have two birches which they are loth to believe can be age variations only.... [The black birch's] range as well as its abundance in Michigan, Wisconsin, Minnesota, and Iowa is unknown. In short, the two birches *B. lenta* and *B. lutea* have been so confounded by lumbermen and botanists that no dependence whatever can be placed on any published statement as to either range or frequency of the black birch in the north, northeast, or northwest.

Reports of these dark-barked birches led to many exaggerations of the range of the sweet birch. When Fassett (1932) described the dark-barked birch taxon as a form of yellow birch, he stated, "This tree occurs in company with typical *B. lutea,* and differs from it only in having bark closely simulating that of *B. lenta.* Such individuals probably explain numerous sheets in the University herbarium misidentified as *B. lenta,* and perhaps form the bases of reports of the cherry birch from this state [Wisconsin]." Similarly, in Minnesota, Rosendahl (1916) recognized that several specimens collected in that state and called *B. lenta* were not identified correctly and "the specimens can therefore be referred to *B. lutea* without any doubt whatever." He was working with herbarium material and concluded this without realizing that they were probably misidentified because of their bark. Similar records in southern Michigan and northern Indiana of sweet birch localities (Beal, 1905; Bingham, 1945; Cole, 1901; and Pepoon,

1927) probably reflect the occurrence of this form. As recently as 1958, Harlow and Harrar continued to show the southern third of the Lower Peninsula of Michigan within the range of sweet birch, though there are no confirmed localities for the species there.

At the time when both *B. lutea* and *B. alleghaniensis* were accepted as names for separate taxa, several authors felt that the dark-barked birch was *B. alleghaniensis.* According to Dodge (1921, p. 186), "Professor C. S. Sargent . . . is inclined to call this birch *Betula allegheniensis* Britton, southern yellow birch, and doubts whether we have *Betula lenta* L., cherry birch, in Michigan or western Ontario." In Nova Scotia, Fernald (1921) felt that reported specimens of sweet birch were actually *B. lutea* var. *alleghaniensis* (Britton) Ashe. In Indiana, Deam (1921) referring to yellow birch, stated:

> That there are geographic races or Mendelian segregates of this species is evidenced by the different interpretations given this species by different authors. *Betula alleghaniensis* Britton appears to be one of them. The descriptive difference between *Betula lenta* and *Betula lutea* is not clear, which has resulted in many authors crediting *Betula lenta* to Indiana and the area west of Indiana.

The morphological characteristics of this confusing, dark and tight-barked birch, in view of the apparent east of hybridization between the birches (Dancik, 1967), have suggested that this taxon may be a hybrid between sweet birch and yellow birch. Britton's original description of *B. alleghaniensis* (1904) indicated that his new taxon was easily and often confused with both sweet birch and what he called *B. lutea,* suggesting the possibility of hybridization. Others felt that *B. alleghaniensis* was in fact this hybrid. Eames (Harger et al., 1917) recognized this possibility from specimens he examined in Connecticut: "A form which is intermediate between, and possibly a hybrid of, this species [*B. lenta*] and *B. lutea* has been described as *B. alleghaniensis* Britton and is rare in the western part of the state." Deam (1921) felt that at least some of the peculiar forms of yellow birch found in Indiana could be accounted for by hybridization with sweet birch. Braun (1961) suggested that many individuals of *B. lutea* forma *fallax* Fassett in Ohio could be confused with sweet birch and under the latter observed that ". . . combinations of characters shown by some specimens from northeastern Ohio suggest hybridization" with yellow birch. This hybrid interpretation is rather inconsistent in the many areas where the unusual birch occurs but the sweet birch does not.

Professors Burton V. Barnes and Warren H. Wagner, Jr., and I have found many of these unusual birches in and around several swamps and lakes in Washtenaw, Jackson, Kalamazoo, and Allegan counties in Michigan. A detailed study was made of one population at Walsh Lake, Washtenaw County, Michigan, and will be reported elsewhere. The distinctive bark of these birches (Fig. 1) is rivaled in interest by their pistillate bracts, many of which are quite glabrous and so variable in shape that they can be easily confused with those of sweet birch, paper birch (*B. papyrifera* Marsh.), or river birch (*B. nigra* L.) (Dancik, 1967). At this time it appears that these forms are not sufficiently genetically distinct to warrant specific, or for that matter, infraspecific, status. Enough biotypes with bark types similar or intermediate to those of "normal" yellow birch appear in these populations to indicate that the dark-barked character is not true breeding

or particularly unique. Similarly, none of the pistillate bract forms at Walsh Lake are particularly unique or dominant. This was hinted at by Hanes and Hanes (1947) when they mentioned that in Michigan "Where the species and the variety [*B. lutea* var. *macrolepis* Fernald] both occur, . . . trees intermediate between

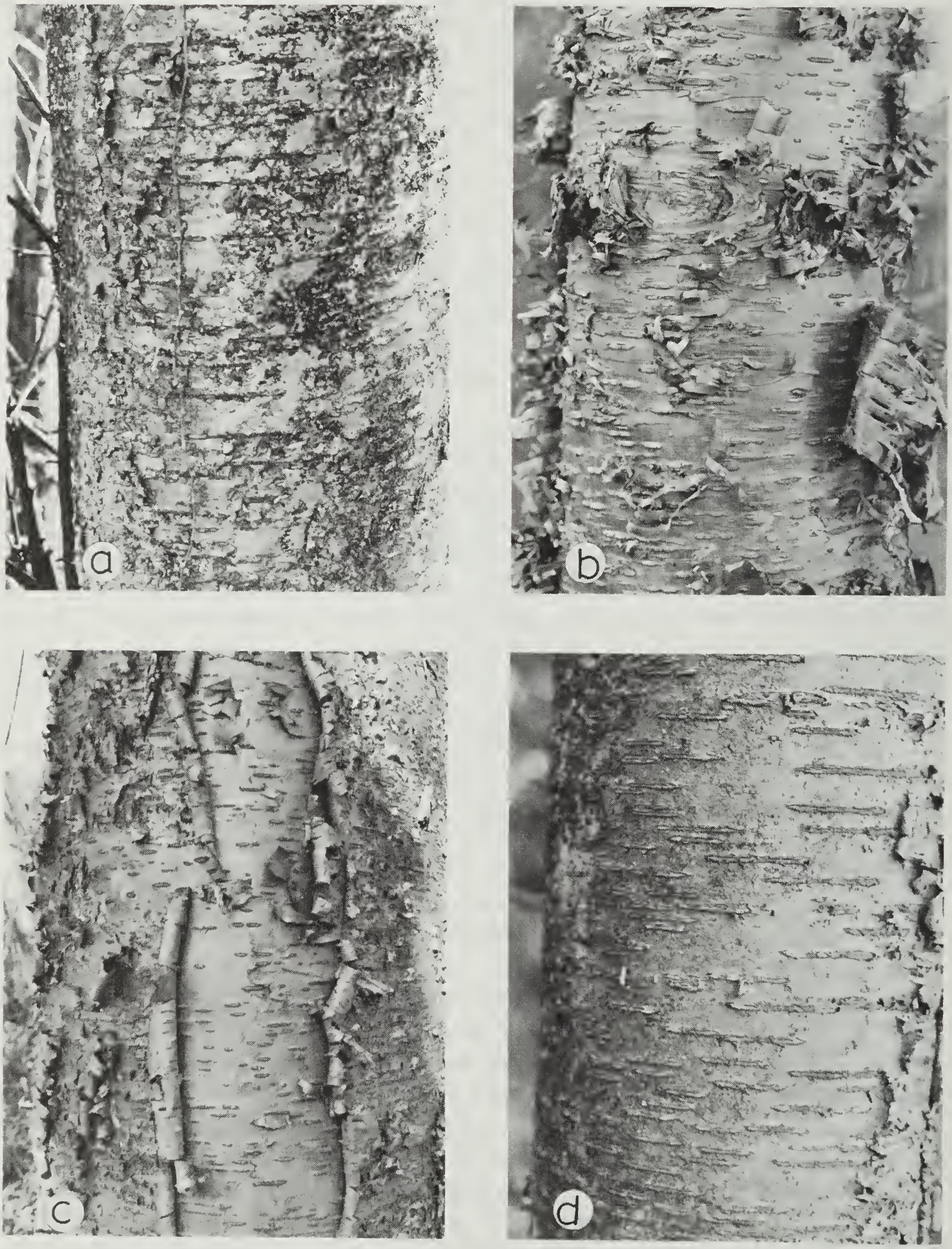

Fig. 1. Bark of representative yellow birches at Walsh Lake. a) Tree 1, 13.6 in. dbh; b) tree 19, 8.0 in. dbh; c) tree 44, 15.0 in. dbh; and d) tree 64, 8.4 in. dbh.

the two can be found." Evidently these dark-barked birches (with highly variable pistillate bracts) are yellow birches with the bark characteristics influenced by the local environment, genetic differentiation subsequent to isolation from the more northerly and easterly portions of the gene pool of yellow birch, or introgressed genes from bog birch (*B. pumila* L.), a plant that frequently hybridizes with yellow birch in this area (Dancik, 1967). However, the possibility of introgression is not supported by present evidence. Studies are underway to compare yellow birches of northern Michigan with those of southern Michigan and further clarify the identity of the dark-barked forms.

Any readers knowing of localities for yellow birches in the southern Lower Peninsula of Michigan or adjacent parts of Indiana, Ohio, and Illinois are encouraged to contact the author.

ACKNOWLEDGMENTS

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Harlow, William M., & Ellwood S. Harrar. 1958. Textbook of Dendrology. Fourth Edition. McGraw-Hill Book Co., New York. 561 pp.

Little, Elbert L., Jr. 1953. Check List of Native and Naturalized Trees of the United States (Including Alaska). U.S. Dep. Agr. Handb. 41. 472 pp.

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AN UNUSUAL FRUITING OF *ASTEROPHORA LYCOPERDOIDES*

Florence V. Hoseney
Herbarium, The University of Michigan, Ann Arbor

Atmospheric conditions in southeastern Michigan in 1968 were very favorable for the fruiting of mushrooms. The total rainfall in May, June, and July was 16 inches. This included a flood in June which resulted in the water in most ponds and marshes remaining nearly one and a half feet above the normal level for most of the summer. High humidity and moderate temperatures contributed to maintain an exceptional fruiting of mushrooms over a much longer period than in most years.

Not only were common species out in great numbers but also the rarer ones appeared in surprising quantity. One of these which appears to be of special interest, *Asterophora lycoperdoides* (Bull.) Ditmar ex Fr. (Fig. 1), was found in a pine plantation at the University of Michigan Stinchfield Forest near Dexter, Washtenaw County, Michigan, on July 25, 1968. This fungus is considered very rare and usually only one or two specimens are found during a good season; but upon this occasion Mrs. Ruth Zehner and I in two hours collected more *A. lycoperdoides* than we could carry (three market baskets full), from one small area. In October, it fruited again and an equal amount was gathered.

This species of *Asterophora* was found parasitizing *Russula nigricans. A. lycoperdoides* is a cantharelloid fungus, which means it has thick gills with obtuse edges, though in many specimens the gills are poorly formed. The young caps are white and moist, becoming dry and brown at maturity and breaking up into a mass of powdery chalamydospores. It probably reproduces more readily by means of the chlamydospores, which form from the breaking up of the pileus, than from basidiospores. In a second species, *A. parasitica,* basidiospores form more regularly.

Further study of *A. asterophora* might be of interest. For instance, this parasite preserves the host mushroom for a considerable length of time (two weeks), suggesting antibiotic properties. Technical information about *Asterophora (Nyctalis)* can be found in *A Monograph of Cantharelloid Fungi* by E. J. H. Corner (Oxford University Press, 1966).

The host, *Russula nigricans,* seemed to prefer the "trashier" sections of the pine plantation where trees had been cut down and left to rot or lower branches had been trimmed but not cleared away, thus creating a debris-laden floor rather than a clean, needle carpet over the earth.

Uninfested *Russulae* were few, but time did not permit thorough coverage of the entire forest. Such an investigation appeared overwhelming because there were several hundred basidiocarps in one small area alone. A large collection is preserved in the Herbarium of the University of Michigan as a record of this fruiting.

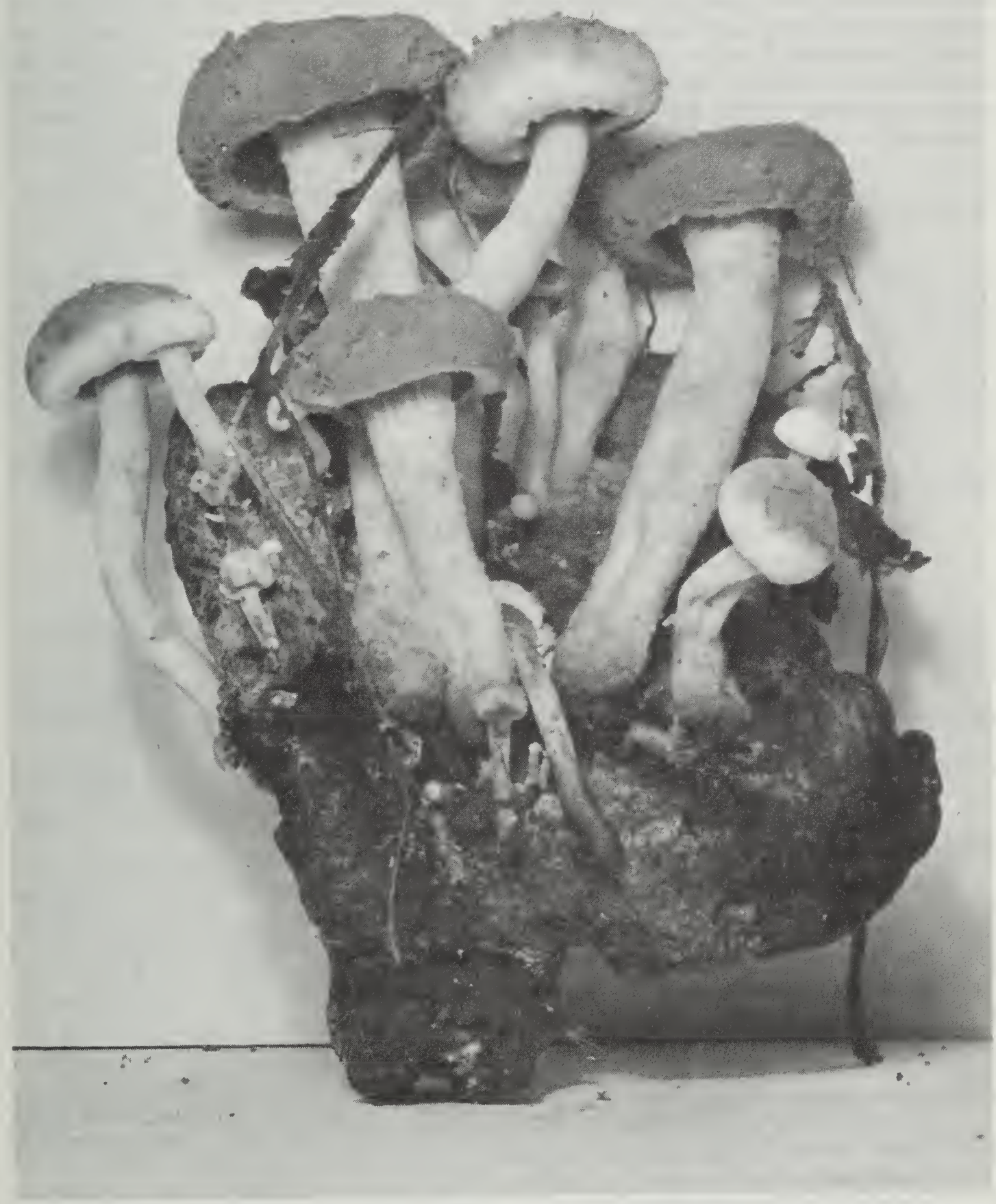

Fig. 1. *Asterophora lycoperdoides* (Smith 6907).

MICHIGAN PLANTS IN PRINT

New Literature Relating to Michigan Botany

This section lists new literature relating to Michigan Botany under four categories: A. Maps, Soils, Geography, Geology (new maps and selected bulletins or articles on soils and geology as these may be of use to field naturalists and students of plant distribution); B. Books, Bulletins, etc., and C. Journal Articles (listing, respectively, all separate publications and articles in other periodicals which cite Michigan specimens or include research based on plants of wild origin in Michigan;—not generally including work on cultivated plants nor strictly economic aspects of forestry, conservation, or agriculture); D. History, Biography, Exploration (travels and lives of persons with Michigan botanical connections). When the subject matter or relation to Michigan is not clear from the title, annotations are added in brackets. Readers are urged to call to the editor's attention any titles (1960 or later) which appear to have been overlooked—especially in less well known sources.

A. MAPS, SOILS, GEOGRAPHY, GEOLOGY

The following topographic maps for Michigan have been published by the U. S. Geological Survey, 1200 S. Eads St., Arlington, Virginia 22202, since the previous listing in our January, 1968. issue. All are 7½-minute quadrangles (scale of 1:24,000 or about 2½ inches to a mile). Maps are supplied with green overprint showing wooded areas unless request is made to the contrary. Standard topographic quadrangle maps are $.50 each, and maps in the 1:250,000 series are $.75 each, with a 20% discount on orders totalling $20.00 or more.

Following the name of the quadrangle, the county or counties in which it primarily lies are added in brackets in the list below:

Alabaster [Iosco, Arenac]
Au Gres [Arenac]
Au Sable Point [Alger]
Au Sable Point SE [Alger]
Au Sable Point SW [Alger]
Grand Sable Lake [Alger]
National City [Iosco, Arenac]
Point Lookout [Arenac]
Toledo (revised) [Monroe, plus Ohio]

Limited revisions of the following sheets in the 1:250,000 series have been issued: Escanaba (NL 16-8), Flint (NK 17-1), Midland (NK 16-3), and Toledo (NK 17-7).

Chiappetta, Jerry. 1968. Great Lakes, Great Mess. Audubon 70(3): 30-45. [A timely, but unpleasant, article on pollution, with considerable reference to Michigan and many data on the Great Lakes.]

(Grand Mere Association) [1968] Unique Grand Mere. [20] pp. [Well illustrated account of geological and cultural history of this Berrien Co. area, with lists, by common name only, of trees and some of the other plants which inhabit it. Copies of the booklet are available from The Grand Mere Association, Box 140, Stevensville, Michigan 49127.]

Kelley, R. W., & W. R. Farrand. 1967. The Glacial Lakes Around Michigan. Dep. Conservation, Geol. Surv. Bull. 4. 23 pp. [A concise history, with dates, of the various ice advances in Michigan, and the related moraines and stages in development of the Great Lakes.]

Kirkby, E. A. 1967. Index to Michigan Geologic Theses. Dep. Conservation, Geol. Surv. Circ. 7. 33 pp. [List of 387 master's and doctor's theses from 26 Michigan and other institutions, arranged alphabetically by author, with full titles; two-page subject index. Most, but not all, were written since 1930. Includes no citation of number of pages and no indication as to whether thesis has been published. One unexpected omission is George Babcock Cressey's classic "The Indiana Sand Dunes and Shore Lines of the Lake Michigan Basin" (Univ. Chicago, 1923; published 1928).]

B. BOOKS, BULLETINS, SEPARATE PUBLICATIONS

Chase, Clarence D. 1968. Michigan's Timber Volume. North Central For. Exp. Sta., U. S. For. Serv. Res. Note NC-50. 4 pp. [Gives tables on volume of growing stock and volume of sawtimber on commercial forest land, by counties and species groups. General comparisons are made between the 1966 data presented and 1955 data.]

Neal, James. 1967. Familiar Trees of Michigan. Mich. St. Univ. Extension Bull. E-616. 22 pp. [Compiled for 4-H Club members and others, with illustrations, brief comments, and illustrated terminology, for some of the native and planted trees. Sloppy errors in spelling and otherwise. Drawing of "American Hornbeam (*Ostrya virginiana*)" is actually fruiting *Carpinus caroliniana;* drawing of eastern cottonwood looks more like quaking aspen; several of the fruit and leaf types illustrated on the last two pages—e.g., ginkgo—do not apply to any of the species included in the booklet. The key does not cover the same species as are illustrated, includes several statements without alternative contrasts, and hence is often impossible to use. Although free, the booklet is hardly worth the postage to request it.]

Peterson, Roger Tory, & Margaret McKenny. 1968. A Field Guide to Wildflowers. Boston, Houghton Mifflin Co., 420 pp. $4.95 [Distribution stated for a number of species mentions Michigan. See review in Mich. Bot. 7: 190.]

Scora, Rainer W. 1967. Interspecific Relationships in the Genus Monarda (Labiatae). Univ. Calif. Publ. Bot. 41. 71 pp. $2.50 [Maps in this monograph show *M. didyma, M. punctata,* and *M. fistulosa* in Michigan; "representative specimens" (2 and 1, respectively) are cited from Michigan only for the latter two species.]

Thomson, John W. 1967. The Lichen Genus Cladonia in North America. Univ. Toronto Press. 172 pp. $12.75 [Michigan included in the range stated in the key for several species, and several other species are illustrated by photos of Michigan specimens. Although Michigan and Colorado are mentioned in the key to *C. carneola,* the range stated for this species in the text would seem to exclude these states. Useful introduction and illustrations on such topics as lichen chemistry.]

C. JOURNAL ARTICLES

Brewer, Richard. 1966. Notes on vegetation and birds of a maple forest in southwestern Michigan. Jack-Pine Warbler 44: 48-49. [Includes some vegetational data on a tract in Kalamazoo Co.]

Clausen, Knud E. 1968. Variation in height growth and growth cessation of 55 yellow birch seed sources. North Central For. Exp. Sta., U. S. For. Serv. Res. Pap. NC-23 (Proc. 8th Lake States For. Tree Improvem. Conf.): 1-4. [Five of the sources from which seed was evaluated were in Michigan.]

Core, Earl L. 1968. The range of Carex trichocarpa Muhl. Castanea 33: 151-152. [Map includes dots in Ingham and Washtenaw cos.; records from Kent and Genesee have also been published by Hermann.]

Culberson, William Louis, & Chicita F. Culberson. 1968. The lichen genera Cetrelia and Platismatia (Parmeliaceae). Contr. U. S. Natl. Herb. 34: 449-558. [*C. olivetorum* cited and mapped from Isle Royale; *P. glauca* and *P. tuckermanii* also cited from Isle Royale but not mapped there, though other Michigan collections of the latter are mapped.]

Curtis, E. J. C., & J. E. Cantlon. 1968. Seed dormancy and germination in Melampyrum lineare. Am. Jour. Bot. 55: 26-32. [Material from Crawford Co.]

Davis, H. A., Albert M. Fuller, & Tyreeca Davis. 1968. Contributions toward the revision of the Eubati of eastern North America. II. Setosi. Castanea 33: 50-76. [Reports type of *Rubus notatus* var. *boreus* (Kalkaska Co.) is inadequate for evaluation; several species credited to Michigan: *R. dissensus, R. junceus, R. superioris, R. wheeleri, R. spectatus, R. regionalis, R. wisconsinensis, R. angustifoliatus* (?), *R. glandicaulis, R. perspicuus, R. missouricus* (incl. *R. mediocris* & *R. jejuns*); *R. conabilis* not evaluated.]

Dudley, Theodore R. 1968. Alyssum (Cruciferae) introduced in North America. Rhodora 70: 298-300. [*A. alyssoides* said to be naturalized in Michigan.]

Fenwick, Mason G. 1968. Lake Huron distribution of Tabellaria fenestrata var. geniculata A. Cleve and Coelastrum reticulatum var. polychordon Korshik. Trans. Am. Micr. Soc. 87: 376-383. [Considerable data from Michigan side of the lake.]

Gibbons, J. Whitfield. 1968. Carapacial algae in a population of the painted turtle, Chrysemys picta. Am. Midl. Nat. 79:517-519. [Work done in "a marsh in southwestern Michigan."]

Hale, Mason E., Jr. 1967. New taxa in Cetraria, Parmelia, and Parmeliopsis. Bryologist 70: 414-427. [Distribution map for *P. ambigua* includes three dots in Michigan.]

King, James P. 1968. Seed source variation in tracheid length and specific gravity of five-year-old jack pine seedlings. North Central For. Exp. Sta., U. S. For. Serv. Res. Pap. NC-23 (Proc. 8th Lake States For. Tree Improvem. Conf.): 5-9. [Three of 34 seed sources used were in Lower Peninsula.]

Lester, Donald T. 1968. Variation in cone morphology of balsam fir, Abies balsamea. Rhodora 70:83-94. [Although map indicates that collections were made in Michigan, no Michigan data are included in tables and text.]

Maas, W. S. C. 1967. Studies on the taxonomy and distribution of Sphagnum IV. Nova Hedwigia 14: 187-214. [Cites Michigan specimens of *S. majus* and *S. annulatum* var. *porosum,* and the stations are included on maps.]

Mangaly, Jose K. 1968. A cytotaxonomic study of the herbaceous species of Smilax: Section Coprosmanthus. Rhodora 70: 55-82; 247-273. [Michigan material cited and mapped for *S. lasioneuron* (sic), *S. illinoensis,* and *S. ecirrhata* (sic)—the second of these a new species intermediate between *S. lasioneura* and *S. ecirrata.* Citations are riddled with careless errors (at least 25 errors in 31 Michigan citations, mostly involving spelling of names of collectors or localities). Chromosome numbers for *S. lasioneura* (2n = 26) and *S. illinoensis* (n = 13, 2n = 26) are given for Washtenaw Co. material.]

McGregor, Ronald L. 1968. The taxonomy of the genus Echinacea (Compositae). Univ. Kan. Sci. Bull. 48: 113-142. [*E. pallida* cited from Beaver Island and Baraga Co., mapped at latter and two other locations; *E. purpurea* mapped in Michigan but no specimens cited.]

Miller, H. E., et al. 1968. Infraspecific variation of sesquiterpene lactones in Ambrosia psilostachya (Compositae). Am. Jour. Bot. 55: 316-324. [One of the collections studied was from "Michigan."]

Nilsson, Siwert. 1967. Pollen morphological studies in the Gentianaceae—Gentianinae. Grana Palyn. 7: 46-145. [The pollen studied and illustrated of *Swertia caroliniensis* was from Michigan (coll. Camps in 1897, presumably Jackson Co.) and that studied of *Halenia deflexa* was also from the state (Dodge in 1894).]

Owston, Peyton W. 1968. Multiple flushing in eastern white pine. For. Sci. 14: 66-67. [Double branch whorls observed in southeastern Michigan—whether on native or planted saplings is not stated.]

Pringle, James S. 1967. Royal Botanical Gardens herbarium. Gardens Bull. (Hamilton, Ontario) 21(3): 9-24. [One of the representative specimens illustrated is *Solidago houghtonii* from the shore of Douglas Lake, with comment on the unusual inland location.]

Rexrode, Charles O. 1968. Tree-wounding insects as vectors of the oak wilt fungus. For. Sci. 14: 181-189. [Map of reported distribution of oak wilt in U. S. (through 1964), by counties, shows occurrence in southern Michigan.]

Richards, Edward Leon. 1968. A monograph of the genus Ratibida. Rhodora 70: 348-392. [Cites *R. pinnata* from 8 Michigan counties and *R. columnifera* from one (Wayne).]

Sajdak, Robert L. 1968. Variation in bark characters and wood specific gravity of sugar maple. North Central For. Exp. Sta., U. S. For. Serv. Res. Pap. NC-23 (Proc. 8th Lake States For. Tree Improvem. Conf.): 10-14. [Four bark types illustrated by photos; study on trees in Houghton Co.]

Steiner, Erich E. 1968. Dormant seed environment in relation to natural selection in Oenothera. Bull. Torrey Bot. Club 95: 140-155. [Two of the races studied represented Upper Peninsula *O. parviflora.]*

Program Notes

March 16, 1969: State membership meeting, Michigan Botanical Club.

May 23-25: State membership meeting and annual Spring Campout, Michigan Botanical Club: near Irons, Lake Co., in the Manistee National Forest.

Editorial Notes

There is still a need for black and white photographs (no smaller than 5 x 7), of artistic merit, on winter appearance and uses of wild plants, for the Botanical Club's projected publication on "Winter Wildflowers" (see Mich. Bot. 7: 95. March, 1968). Chairman of the committee is Dr. Helen V. Smith, 1766 Glenwood Rd., Ann Arbor, Michigan 48104.

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The October number (Vol. 7, No. 4) was mailed October 23, 1968.

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(On the cover: Tips of willow branches along the Huron River near Island Park, Ann Arbor, photographed by Doug Fulton, February 1968.)

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Articles and notes dealing with any phase of botany relating to the Upper Great Lakes Region may be sent to the editor in chief. The attention of authors preparing manuscripts is called to "Information for Authors" (Vol. 6, p. 202; reprints available from the editor).

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A PHYTOGEOGRAPHICAL ANALYSIS OF A SOUTHERN MICHIGAN BOG

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Pennfield Bog is located in Calhoun County, Michigan. A description and an ecological analysis of the bog were recently presented (Crow, 1969). The present article is concerned with the phytogeography of the floristic composition of the bog.

In order to assess the geographical affinities of a northern bog one must be greatly concerned with the effect of Pleistocene glaciation on the flora of North America. Certainly there is no question that as the ice sheets advanced the vegetation standing in their paths was annihilated. There is much controversy, however, concerning the effect of the glaciers of Wisconsin age on the flora south of the glacial boundary.

One school of thought maintains that there was a major displacement of the boreal forest during Wisconsin glaciation, but "that Full-glacial tundra, boreal forest, and deciduous forest formations were not identical in species composition or even in vegetational structure with their present bioclimatic analogues" (Martin, 1958, p. 378). Whitehead (1965) feels that palynological evidence from Carolina Bay sediments demonstrates beyond doubt profound changes in both climate and vegetation in this region during late Pleistocene time.

On the other hand, some believe that the climate south of the glaciers did not differ greatly from that of the present. Braun (1951, p. 145) maintains that ". . . the deciduous forest zone, although narrowed, maintained itself on the Appalachian Plateaus in southern Ohio and Kentucky while glaciers extended southward in Ohio."

Wolfe (1951) raises two pertinent questions concerning some species of narrow ecological range which are present in microclimates near the glacial border. If a developing tundra caused these species to retreat to the southern Appalachians, ". . . how, with their narrow ecological amplitude and lack of continuous migration routes, did they get back near the glacial border?" And how did a plant like *Sullivantia sullivantii* (T. & G.) Britt., which is known only from limestone and sandstone cliff faces of southern Ohio, southern Indiana and northern Kentucky, return to its present range and ". . . not persist in some of the millions of grotto microclimates of the southern mountains" (Wolfe, 1951, p. 137)?

Iltis (1965, 1966) has observed that there is a large western floristic element in northeastern North America. In the East these western taxa are restricted to glaciated areas. He feels that this distribution pattern strongly suggests that during the Pleistocene the eastern deciduous forests were essentially closed communities and unchanged from those of today, except where subject to periglacial phenomena.

The following phytogeographic analysis takes the latter viewpoint.

The North American ranges of all species in the bog have been determined as accurately as possible from the published literature. Five basic distribution patterns of the Pennfield Bog species are evident: 1) widespread species, occurring throughout much of the United States and adjacent Canada and often widespread in other parts of the world; 2) those occurring primarily in the eastern half of the United States and adjacent Canada; 3) those which occur in northeastern North America and also on the Coastal Plain; 4) those of northeastern North America, primarily north of the glacial boundary; and 5) northern, chiefly circumboreal species.

WIDESPREAD SPECIES

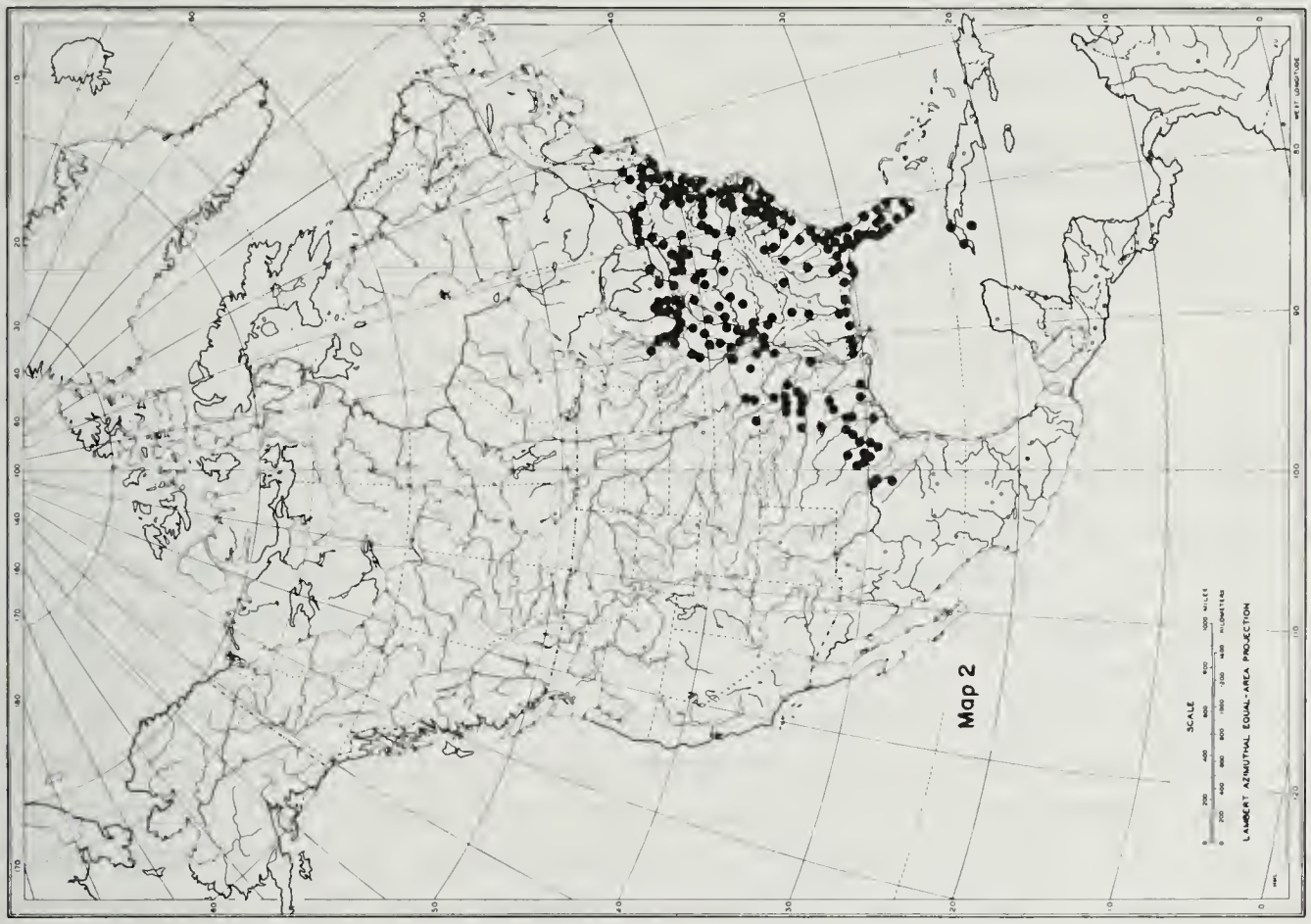
About 10% of the species, of which *Typha latifolia* (Map 1) is an example, occur widely throughout much of the United States. They are chiefly plants of swamps and meadows, quiet waters, and shores. The majority of these plants occur in the pioneer zones and only *Typha latifolia* is an important constituent of the bog. Other species with this distribution include *Agrostis stolonifera, Ceratophyllum demersum, Glyceria striata, Lemna trisulca, Monotropa uniflora, Lemna minor, Potamogeton gramineus, P. illinoensis, Ranunculus sceleratus, Sagittaria latifolia, Scutellaria lateriflora,* and *Sium suave.* These widespread species probably extended their ranges northward as the glaciers receded.

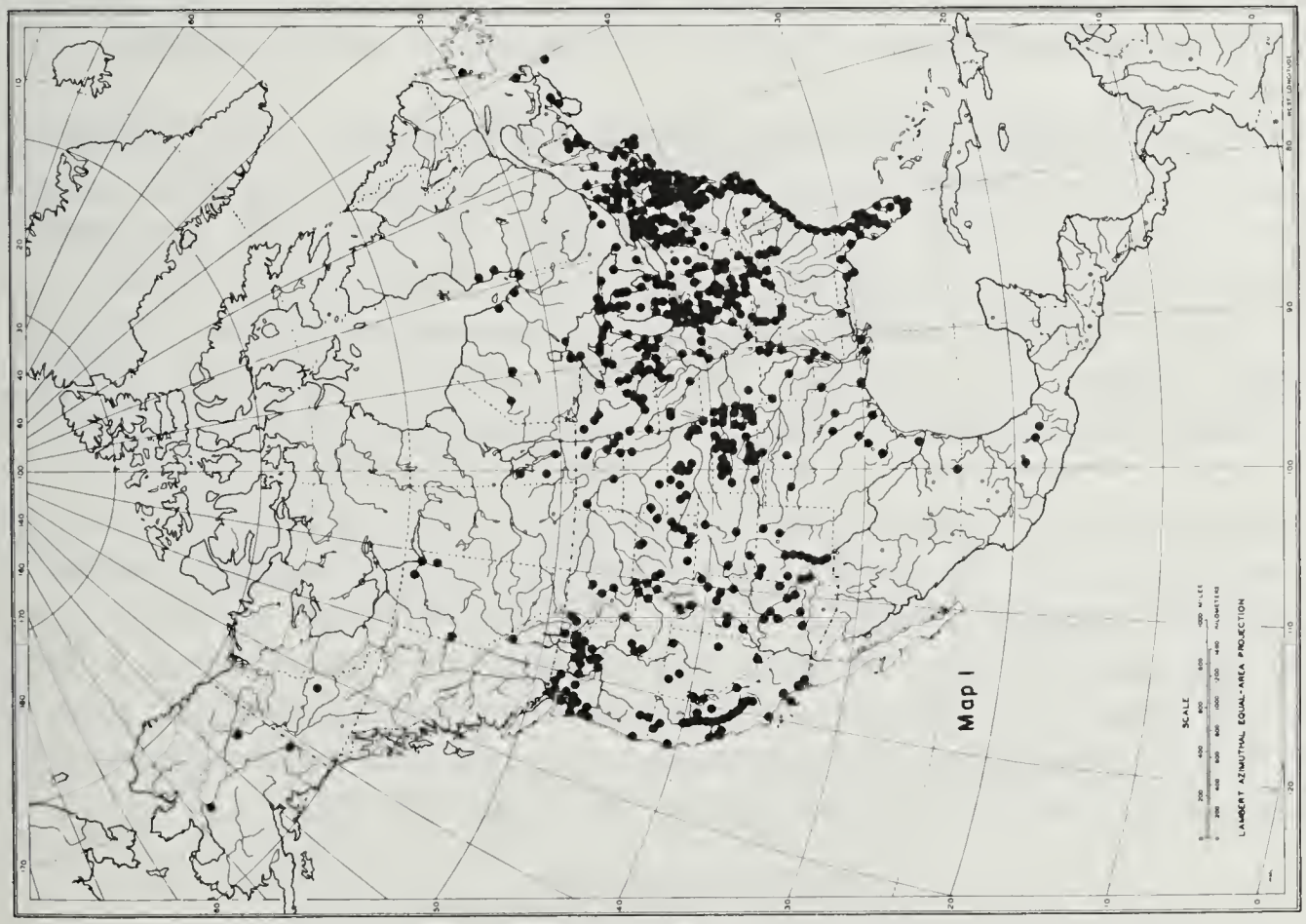
EASTERN UNITED STATES SPECIES

Approximately 26% of the species of the bog have distributions throughout the eastern half of the United States and adjacent Canada. These are species of shores, thickets, swamps and marshes, and woodlands which have also extended their ranges northward with the retreat of the glaciers. *Nuphar luteum* subsp. *macrophyllum* (Map 2), an important pioneer of the bog, illustrates this pattern. Other species with this distribution include *Acer rubrum, Agalinis purpurea, Amelanchier arborea, Apios americana, Boehmeria cylindrica, Brasenia schreberi, Carex comosa, Cephalanthus occidentalis, Cyperus diandrus, Decodon verticillatus, Dulichium arundinaceum, Echinocystis lobata, Eleocharis compressa, Eupatorium perfoliatum, E. purpurea, Impatiens biflora, Juncus effusus* var. *solutus, Leersia oryzoides, Mitchella repens, Nyssa sylvatica, Onoclea sensibilis, Osmunda regalis, O. cinnamomea, Parthenocissus quinquefolia, Polygonum hydropiperoides, P. sagittatum, Prunus virginiana, Quercus velutina, Rosa palustris, Sambucus canadensis, Scirpus cyperinus, Ulmus rubra, Viola affinis, Vitis vulpina,* and *Woodwardia virginica.*

NORTHEAST-COASTAL PLAIN SPECIES

About 8% of the species occur in the Northeast and South along the Coastal Plain. These are mostly plants of acid or peaty soils. *Sarracenia purpurea* (Map 3), a typical bog plant, illustrates the pattern. Most of these plants have apparently migrated northward from the Coastal Plain into the newly





Map 1. Distribution of *Typha latifolia* after Hotchkiss and Dozier, 1949.

Map 2. Distribution of *Nuphar luteum* subsp. *macrophyllum* after Beal, 1956.

opened, glaciated northeast. Other species having this pattern are *Drosera intermedia, Habenaria ciliaris, H. clavellata, Hydrocotyle umbellata* (chiefly a Coastal Plain species), *Isotria verticillata, Pogonia ophioglossoides, Toxicodendron vernix, Triadenum virginicum, Utricularia gibba* (chiefly a Coastal Plain species), and *U. purpurea.*

The ranges of *Habenaria ciliaris, H. clavellata,* and *Isotria verticillata* also extend southward in the Appalachian Mountains. These have probably survived glaciation in the mountains as well as on the Coastal Plain.

NORTHEASTERN NORTH AMERICA SPECIES

Approximately 28% of the Pennfield Bog species are basically of a northeastern North American distribution with nearly the entire range occurring within glaciated territory. The general habitats of this group of plants include bogs, peaty soils, swamps and wet meadows. The distributions of these plants strongly suggest that most of these species survived the Wisconsin glaciation in the Appalachians or on the Coastal Plain, not far from the ice front.

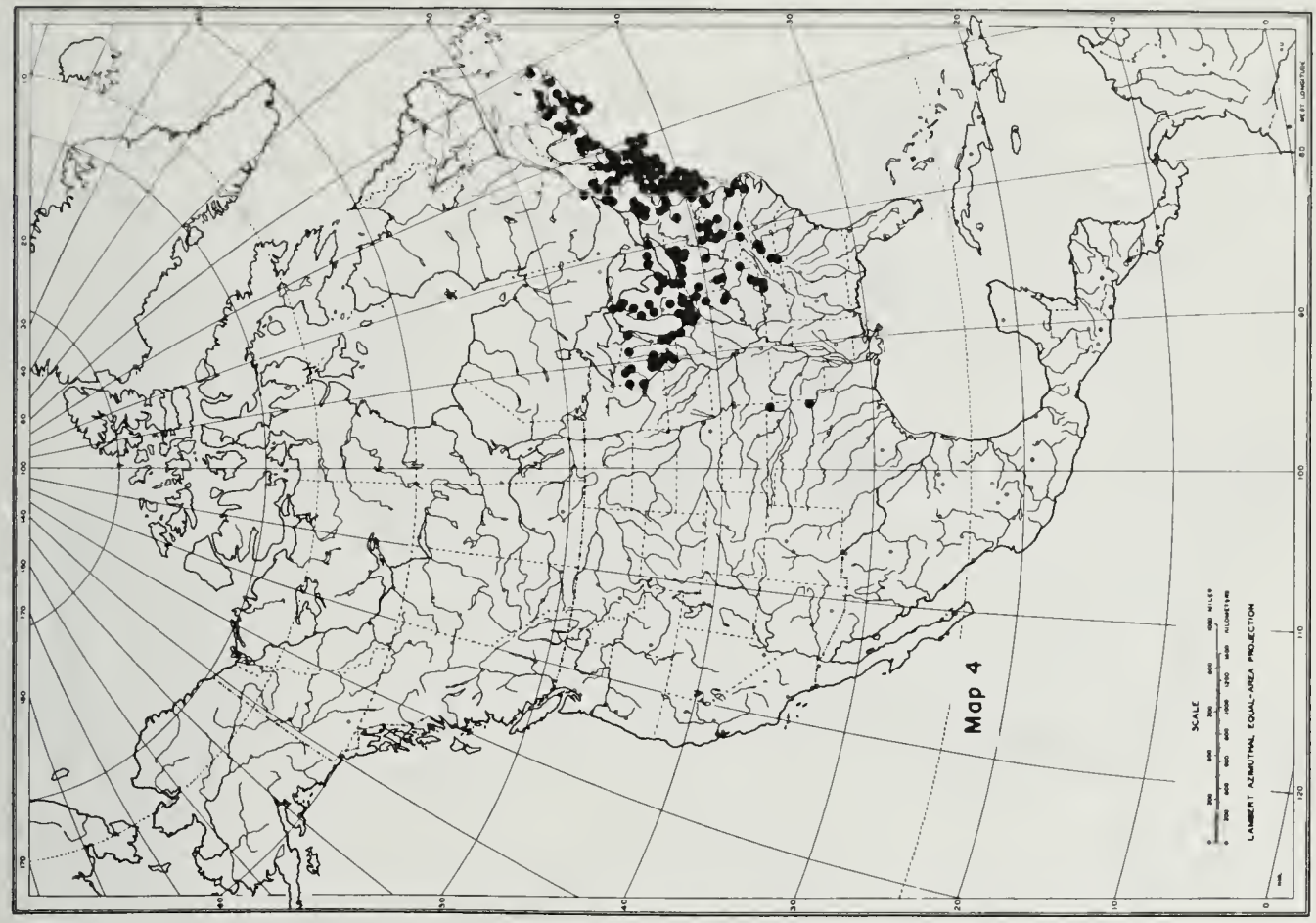
Nearly half of these species occur chiefly in the mountains south of the glacial boundary and include such important species of the bog as *Vaccinium macrocarpon, Nemopanthus mucronata, Ilex verticillatus,* and *Andromeda glaucophylla.* The distribution pattern is represented by *Rubus hispidus* (Map 4). Other species which were apparently harbored by the mountains are *Aronia melanocarpa, Betula lutea, Carex trisperma, Corylus americana, Cypripedium acaule, Eriophorum virginicum, Gaultheria procumbens, Glyceria canadensis, Iris versicolor, Juncus brevicaudatus, Pinus strobus, Ribes hirtellum, Sparganium chlorocarpum, Spiraea tomentosa, Trientalis borealis,* and *Viburnum lentago.*

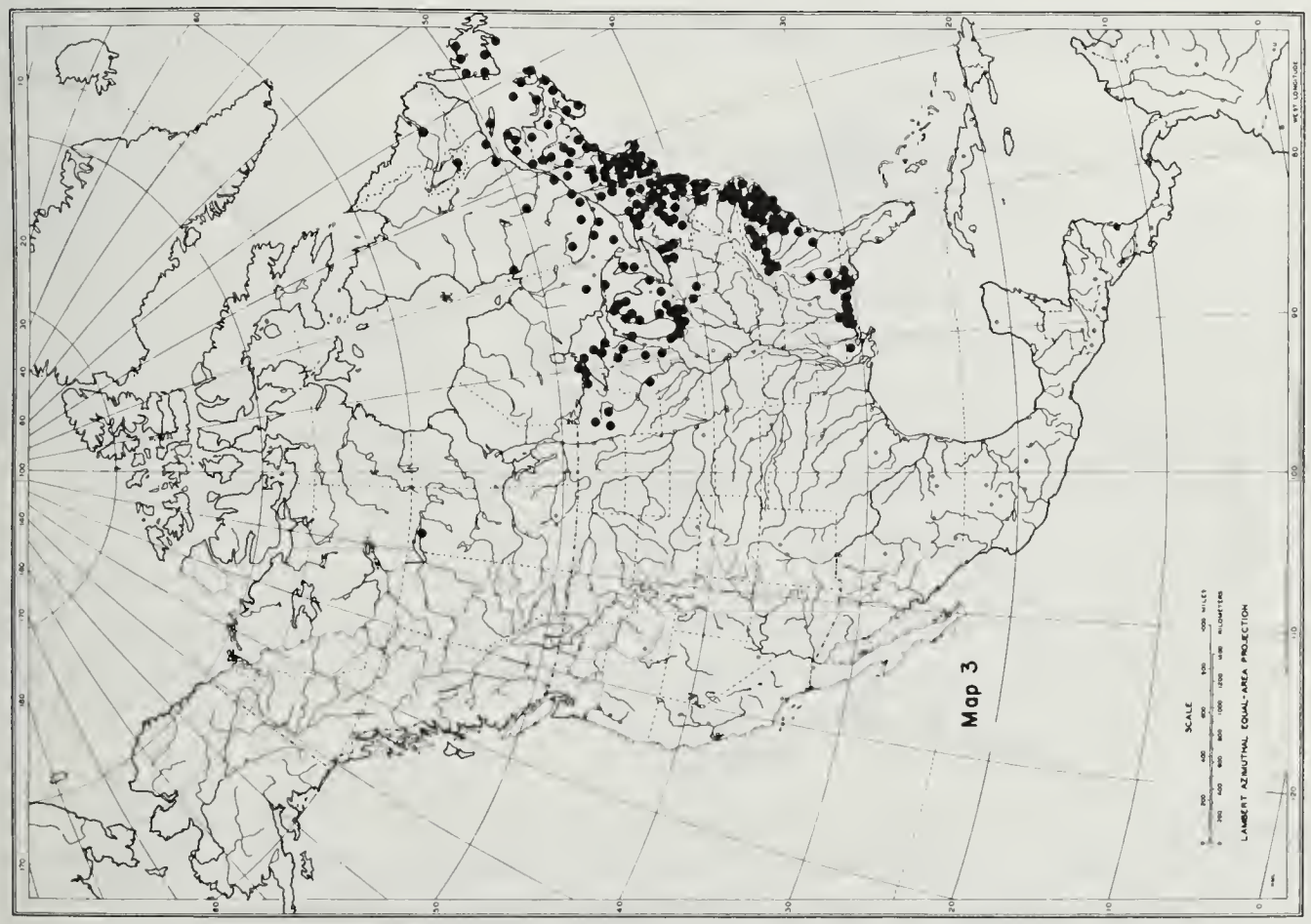
Eleocharis smallii, Thelypteris palustris var. *palustris,* and *Vaccinium corymbosum* are important constituents of the Pennfield Bog flora which apparently persisted chiefly on the coastal plain just south of the glacier. *Rhynchospora alba* (Map 5) illustrates the pattern. Others include *Aster umbellatus, Betula pumila, Bidens coronata, Campanula aparinoides, Cyperus engelmannii, Eleocharis intermedia, Epilobium strictum, Hypericum boreale, Liparis loeselii, Nymphaea tuberosa, Ribes americanum,* and *Rumex orbiculatus.*

Another possible refugium for a few plants with this basic distribution pattern was an area to the southwest of the Great Lakes. *Asclepias incarnata* subsp. *incarnata, Spiraea alba* (Map 6), and *Viola nephrophylla* appear to have migrated into glaciated territory from this refugium. *Spiraea alba* and *S. latifolia,* which apparently survived the Pleistocene in the Appalachians, form a complex centered in glaciated territory where the two taxa come together (for a more detailed discussion of this complex, see Kugel, 1958).

NORTHERN SPECIES

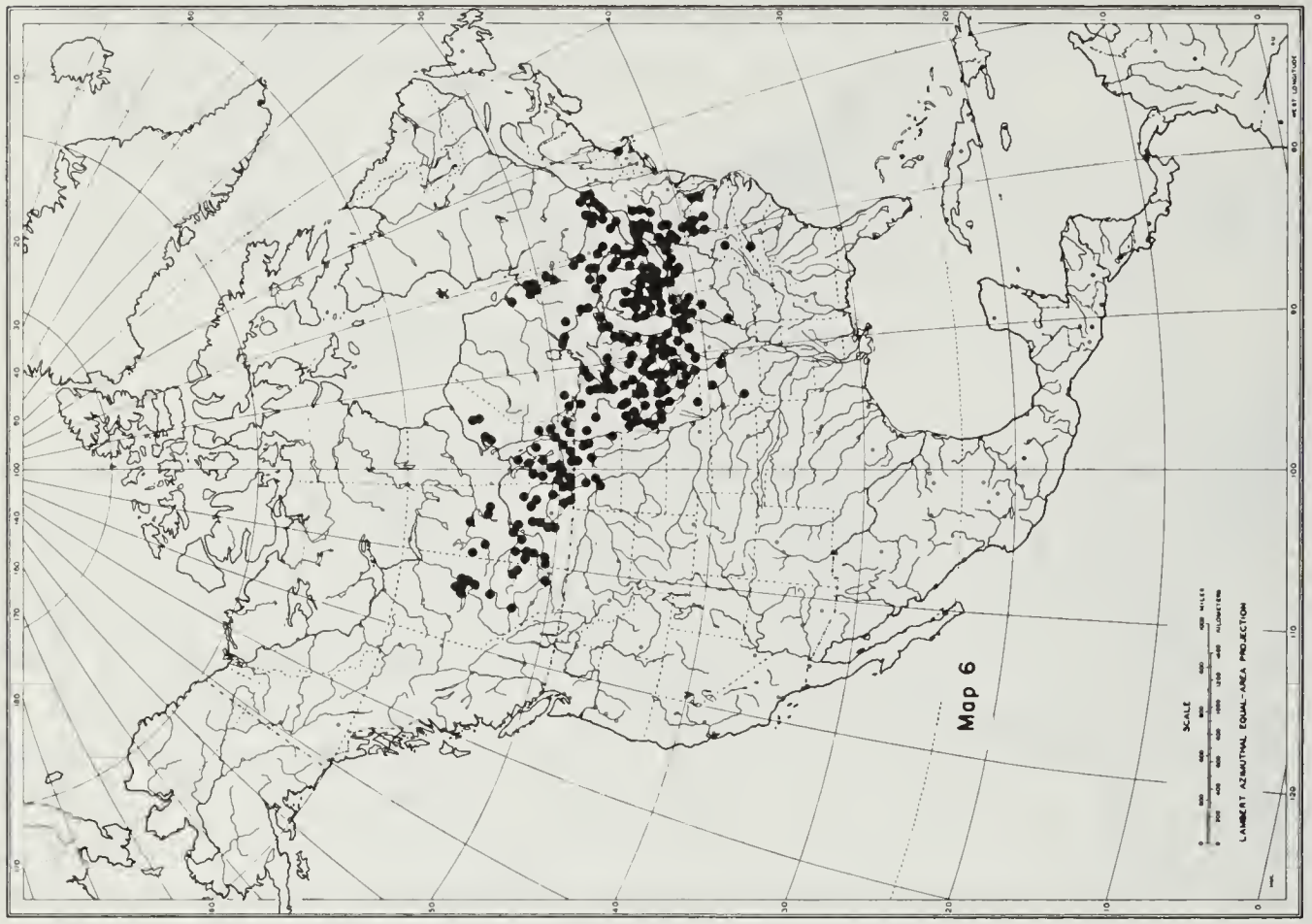
About 28% of the species range throughout much of northern North America; many of these are circumboreal in distribution. Most of them are

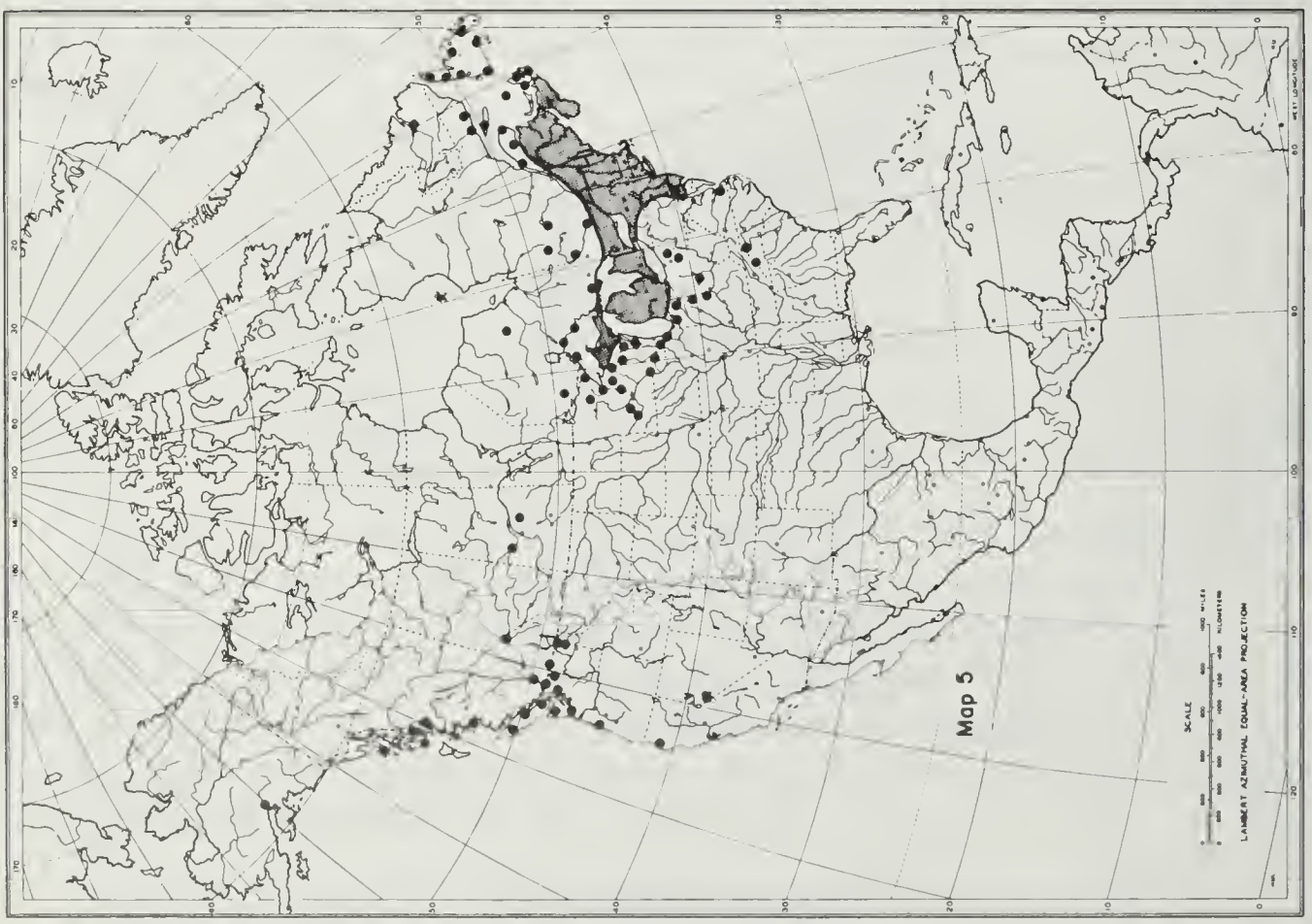




Map 3. Distribution of *Sarracenia purpurea* after McDaniel, 1966.

Map 4. Distribution of *Rubus hispidus* after Braun, 1937.





Map 5. Distribution of *Rhynchospora alba* after Hultén, 1958.

Map 6. Distribution of *Spirea alba* after Kugel, 1958.

plants of bogs and peaty soils, shores, swamps, and marshes. Three of the most important bog species, *Carex lasiocarpa, Cassandra calyculata,* and *Larix laricina,* are in this category.

Nearly one-third of the northern species (9% of the total) occur south of the glacial boundary only in the east and thus appear to have survived glaciation in the Appalachians and the Coastal Plain. *Larix laricina* (Map 7) is illustrative. Others include *Alisma plantago-aquatica, Aralia nudicaulis, Bidens cernua, Cassandra calyculata, Coptis trifolia* var. *groenlandica, Drosera rotundifolia, Habenaria obtusata, Lycopus uniflorus, Maianthemum canadense, Menyanthes trifoliata,* and *Rubus pubescens.*

About half of the northern species of Pennfield Bog (14% of the total) constitutive a western element. Most of the western species survived the Pleistocene in the Rocky Mountains, as is indicated by the distribution of *Cornus stolonifera* (Map 8). These taxa are restricted by the glacial boundary in the East. Other species which probably survived in the Cordillera include *Carex aquatilis, C. interior, Muhlenbergia racemosa* (Iltis, 1965), *Myriophyllum verticillatum, Populus tremuloides* (Iltis, 1965), *Potamogeton natans, Triglochin maritima, Salix candida* (Iltis, 1965), *S. pedicellaris* (Fernald, 1925), *S. petiolaris* and *S. serissima* (Iltis, 1965), and *Urtica dioica* var. *procera.*

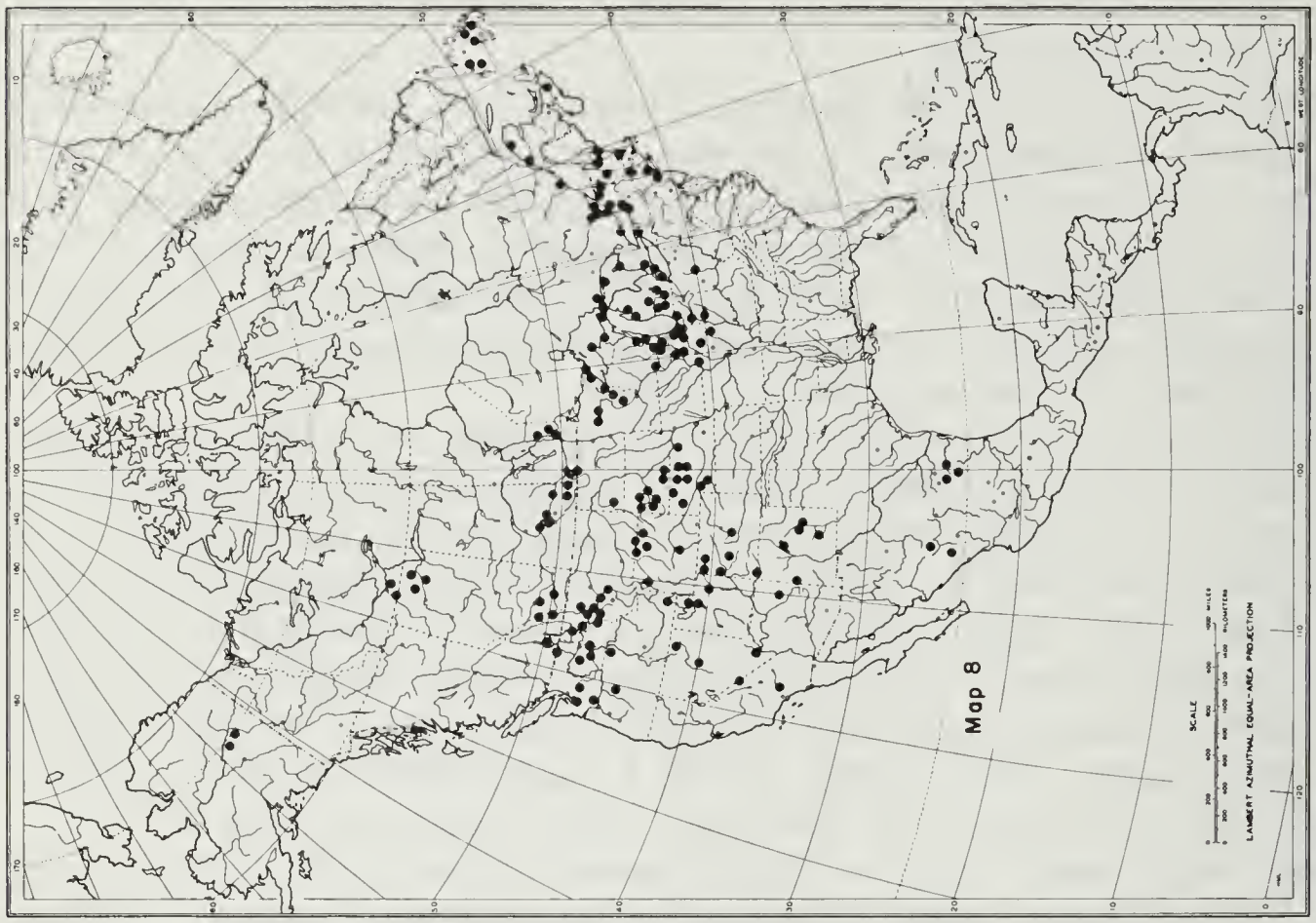
The unglaciated interior of Alaska appears to have enabled many species of the northern forests and of the arctic tundra to survive glaciation (Heusser, 1965). A few species now present in Pennfield Bog have probably migrated from Alaska after the retreat of the ice. The distributions of *Calla palustris* (Map 9), *Carex chordorrhiza*, and *Equisetum fluviatile* suggest such a migration.

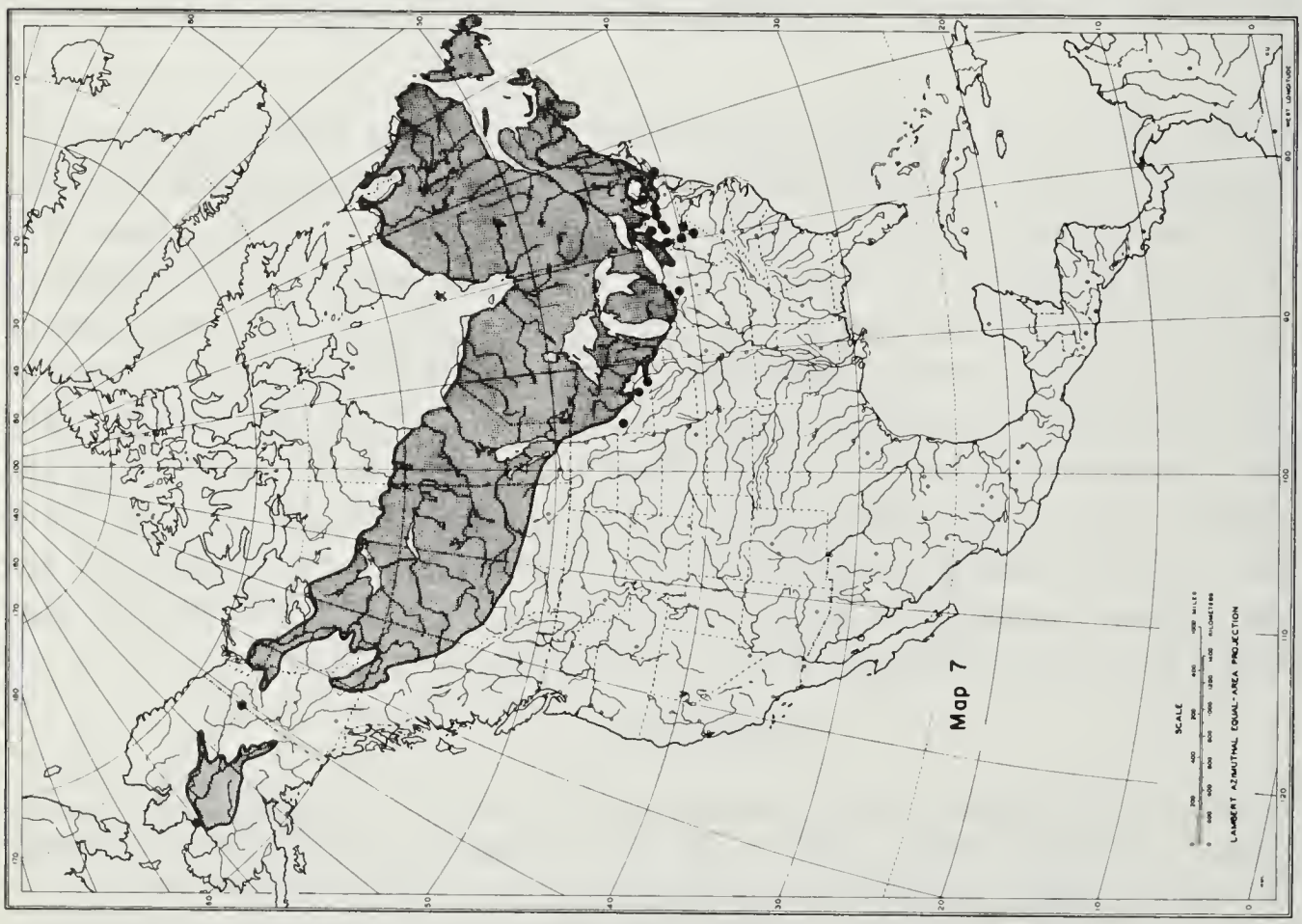
Several species of the bog cannot be accounted for by any of the preceding patterns. Some of these are aquatics whose present ranges are entirely within the glacial boundary and might be considered part of a periglacial element. It is also possible that some of these may have survived on nunataks in and around Newfoundland, as Fernald (1925) has suggested, or in unglaciated coastal refugia of the Pacific Northwest (Heusser, 1965). For some there is insufficient information to allow an assessment of their geographical affinities.

The probable sources of species which now occur in Pennfield Bog are summarized in Map 10. There appear to be four important sources from which the bog flora has been derived: 36% of the species are southern and are chiefly in pioneer zones or at the outer margin of the bog; 42% have an eastern affinity; 10% are Cordilleran; and 2% are of Alaskan affinity.

SUMMARY

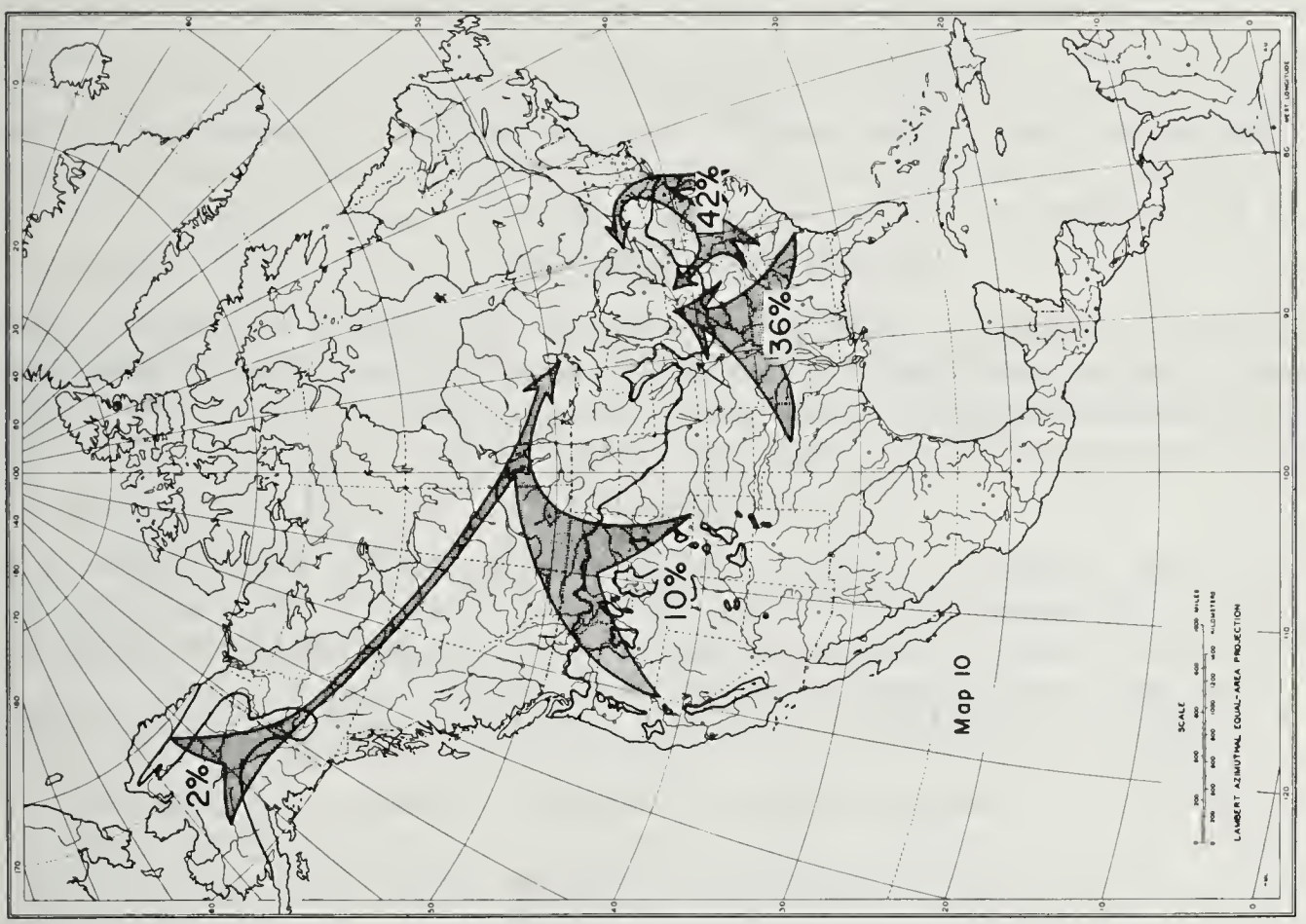
Pennfield Bog, Calhoun County, Michigan, lies in one of the many depressions of the Kalamazoo morainal system. Field work was carried out from April to October, 1967. The bog consists of seven major plant zones: a *Nuphar–Eleocharis* zone, a *Decodon* zone, a *Carex–Vaccinium macrocarpon* zone, a *Cassandra* zone, a *Cassandra–Thelypteris* zone, a *Larix* zone, and an outermost *Acer rubrum* zone. Frequency, cover, and importance values have been tabulated for each vegetational zone.



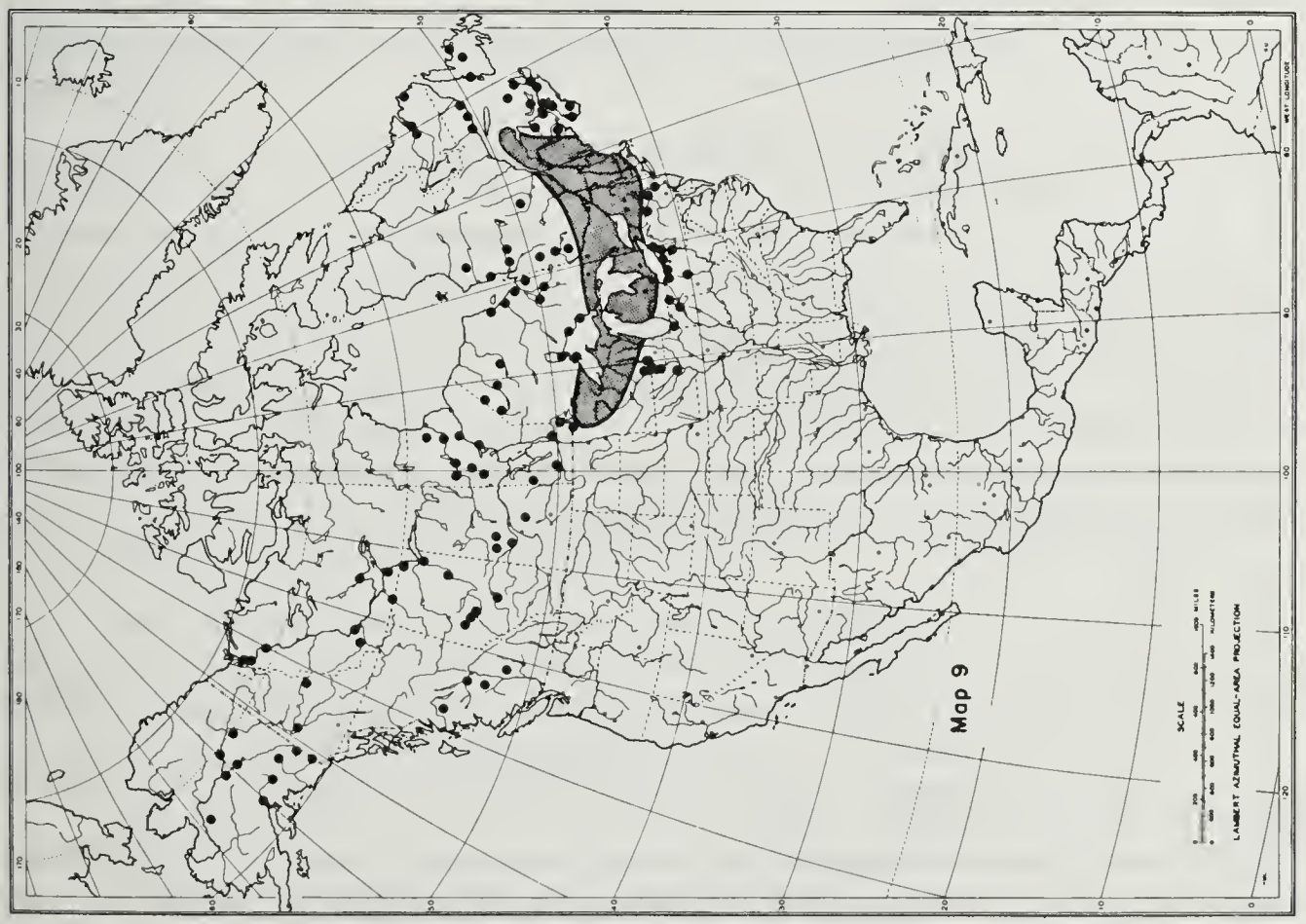


Map 7. Distribution of *Larix laricina* after Little, 1965.

Map 8. Distribution of *Cornus stolonifera* after Rickett, 1944.



Map 10. Migration streams represented in Pennfield Bog and extent of Wisconsin glaciation (glacial boundary after Flint, 1957, 1959).



Map 9. Distribution of *Calla palustris* after Hultén, 1962.

A total of 144 species of vascular plants was collected. Their North American ranges have been determined from the literature. Five basic patterns are represented by the bog species: 1) widespread species; 2) eastern United States species; 3) Northeast-Coastal Plain species; 4) northeastern North American species; and 5) northern species. Postglacial migration from Pleistocene refugia may account for the present flora. The bog flora appears to have been derived from four important sources: 36% of the species have southern affinities, 42% have eastern affinities, 10% represent a Cordilleran element, and 2% are of Alaskan affinity.

ACKNOWLEDGMENTS

In addition to the acknowledgments in the previous article, I wish to thank the Department of Botany and Plant Pathology, Michigan State University, for financial support for publication expenses. The maps are based on Goode Base Map No. 102, copyright by The University of Chicago, and are used by permission.

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WHITE PINE AT THE EDGE OF ITS RANGE, IN OAKLAND COUNTY, MICHIGAN

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In eastern Lower Michigan, white pine (*Pinus strobus*) occurs naturally no farther south than Oakland County. In much of the northeast quarter of that county it occurs as widely scattered single trees or in small groves among hardwoods, and is a familiar volunteer tree as well as a planted tree around lakefront cottages. In other areas of the county, individuals or groups of a few trees occur locally on hummocks in swamps and these occasionally seed into bordering sandy uplands.

A different view is expressed in late nineteenth century accounts, which set the southern boundary in Lapeer County, the next county to the north (Wheeler, 1898; Spalding, 1899). Those observations, however, were probably more concerned with merchantable timber than mere occurrence of white pines, and overlooked branchy, slower growing members of the species in Oakland County. An estimate made just before the turn of the century of 20 acres of standing pine for the whole county (Morse, as quoted by Wheeler, 1898) may reflect similar thinking, for now, even after much clearing of land and lowered water tables, many times that area supports at least a mixture of white pine and other trees. The actual range of white pine probably has remained about the same since presettlement times. Sight records made by the author (1964-1967), of individual stands appearing to be naturally seeded are shown in Fig. 1.

Widely separated outlying stands of white pine occur on the interlobate morainic area extending west-southwest through southern Oakland County, where the surface is a mosaic of hills and lakes amid varied glacial and post-glacial deposits. Observations of one such stand in Springfield Township provide clues to the occurrence and persistance of the species on these sites.

White pines occur in about 15 acres of swamp and adjacent old fields southeast of Davisburg, between Clark and Andersonville roads, NE¼, sec. 21, T4N, R8E, Springfield Township (Fig. 2). A dozen large pine trees approximately 90-100 years old are scattered through a mixed hardwood stand which rims a shrubby sphagnum swamp.

In the swamp several dozen younger pines up to about 70 years of age are growing on broad, low hummocks a little higher than the general surface. These trees are about 50 yards apart and are generally shorter and more widely separated near the center of the swamp.

On the east side of the swamp-fringing hardwood stand, a sandy field, last cultivated twenty-five years ago, has been invaded by a nearly pure stand of very robust young white pines (Fig. 3). These, in turn, are associated with equally robust patches of colic-root (*Aletris farinosa*), trailing arbutus (*Epigaea repens*), and, in season, the edible mushrooms *Suillus brevipes* and *Suillus granulatus* (which possibly forms mycorrhizae with the pines).

Local residents claim that a great number of white pines once grew on the area now occupied by the old field, pasture, and adjacent railroad right-of-way southeast of Davisburg, but were clear-cut in the mid 1800's when the Grand Trunk Railroad was laid. At this time the pine population may have been nearly wiped out, as there are indications that the present swamp was then a marsh or bog and has only recently been invaded by trees. The only surviving pines, after the extensive cutting, would have been seedlings or saplings restricted to a narrow border between field and water.

As hydrarch succession proceeded in the marsh, seedling pines apparently were able to become established on hummocks. More recent abandonment of the formerly cultivated sandy field has allowed old-field succession of pine similar to that long familiar in central New England (Raup, 1964). The population continues to expand at present in spite of grass fires, Christmas tree hunters, and a series of abnormally dry years.

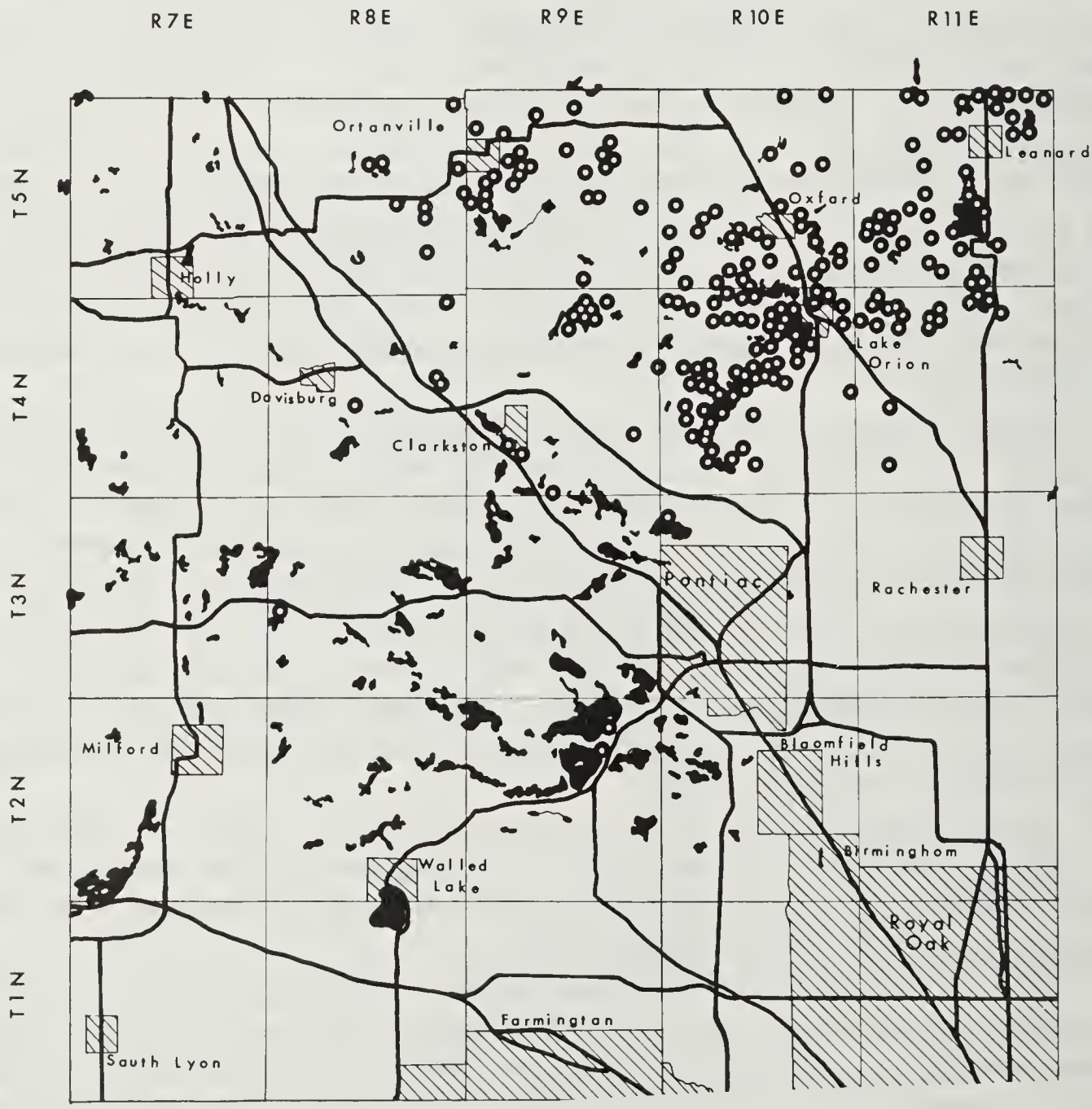

Fig. 1. Sight records of white pine stands in Oakland County, Michigan, 1964-1967.

The aggressiveness of these trees in an area detached from the main range of the species may seem surprising to persons who are inclined to regard plants of more northern range growing in southern Michigan swamps as glacial relicts. Local conditions associated with this particular occurrence, however, provide a favorable habitat in which white pine may not only persist, but achieve dominance.

Three miles northeast, at Bridge Lake, another group of pines exists on a wet slope in association with white cedar (*Thuja occidentalis*). Only a few scattered individuals and small groups occur farther south in the country.

It has long been recognized that throughout the Lake States white pine occurs commonly on sand and near water (Spalding, 1899). Comparison of the Oakland County distribution of this species with a map of Michigan surface formations (Martin, 1955) shows a high correlation with parent materials which are usually sandy in character. Even those pines growing locally on organic soil in bogs are near sandy soil, possibly seeded there from upland trees removed in the last century. Although white pine grows well on a wide variety of soil types (Frothingham, 1914), competition from hardwoods has tended to restrict it to well drained, sandy soils where it may persist as a physiographic climax (Wilson & McQuilkin, 1963). The sandy old field which is presently being invaded by white pine and which may formerly have supported a mature group of these trees appears edaphically suited to maintain such a stand. Those growing in the richer woods and swamp, however, may be regarded as successional intermediates in a hardwood forest (Oosting, 1956, p. 251).

In addition to favorable soil, white pines require a cool, humid climate with a moisture surplus in all seasons (Wilson & McQuilkin, 1963). The numerous lakes and slight elevation of the land (averaging about 1000 ft. above sea level) may contribute to this southern extension in the limit of the species in Oakland County. Predictably, the most southern outliers are found in swamps and around lakes.

The pines in the old field are between a marsh and swamp which are part of the headwaters of the Shiawassee River. The swamp is characterized by slow drainage and cold water. On a hot summer afternoon one may stand among the old-field pines in the shade of the woods, and feel a cool breeze filtering through the trees from across the swamp. A short hike to the west side of the swamp leads to another sandy old field which has been invaded by a lone pine and numerous aspen (*Populus tremuloides*). Here, an equal distance from the water, one feels only the hot afternoon sun. In addition to afternoon shade and a position downwind from the swamp, the field on the east side is downwind from the large pines near the edge of the woods. Seed from these trees falls into patches of *Polytrichum* moss which serve as ideal seedbeds for germination and development of new plants (McQuilkin, 1959).

In the marsh, bordering hardwoods, and adjacent abandoned field, other plants which indicate a greater than usual clustering of more northern species include white birch (*Betula papyrifera*), yellow birch (*Betula lutea*), black spruce (*Picea mariana*), club-moss (*Lycopodium dendroideum*), low-bush blueberry (*Vaccinium* sp.), wintergreen (*Gaultheria procumbens*), and

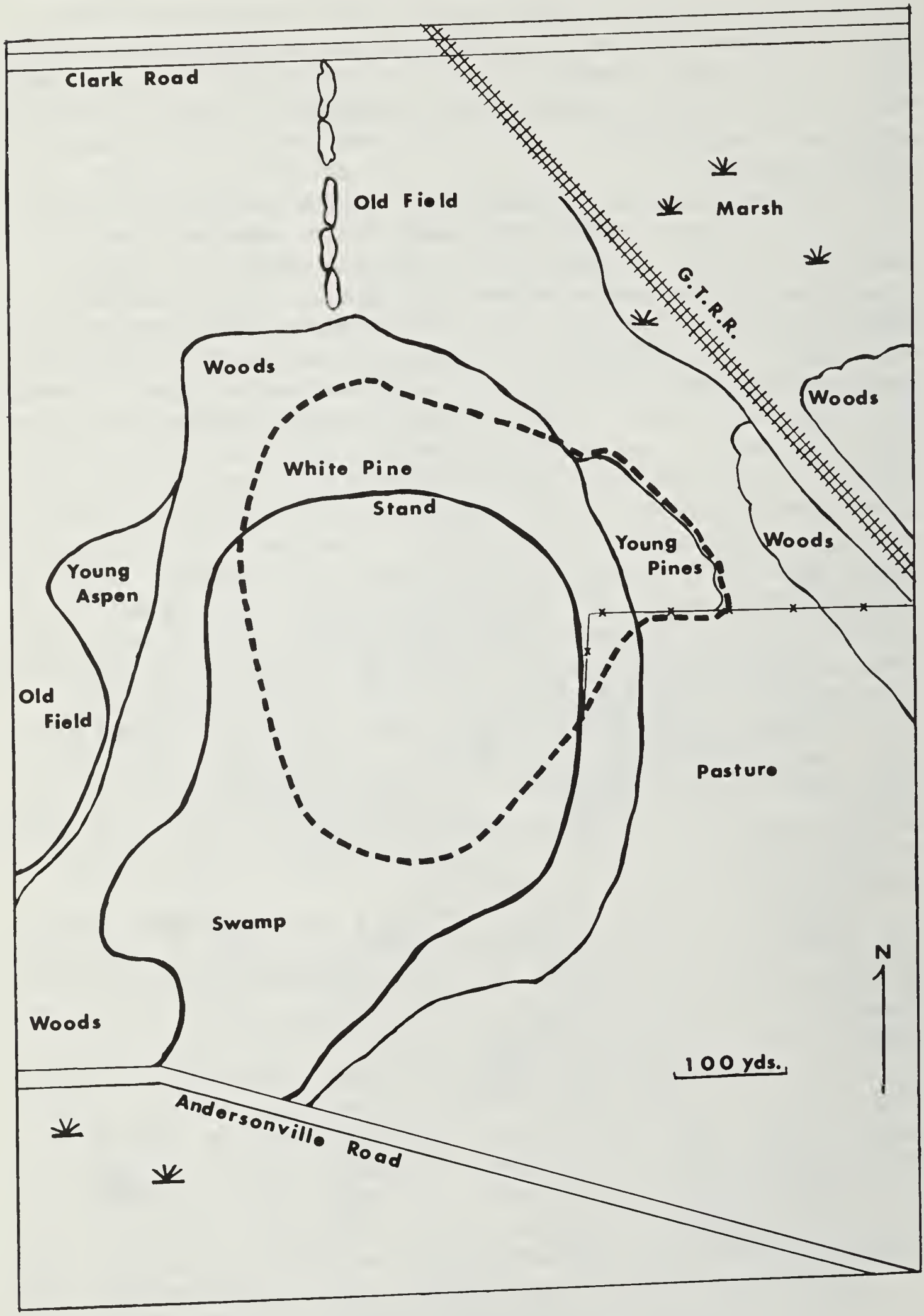

Fig. 2. Location of Springfield Township white pine stand (dashed line) in relation to surrounding features.

partridge-berry (*Mitchella repens*). They are characteristic of a forest type which is common farther north but unusual in this region, the white pine–hemlock–northern hardwoods type.

If left undisturbed this small parcel of vegetation may mature into a localized duplication of a forest type well known to early settlers, and produce rivals of the magnificent white pines of the past which were worthy of being called our State Tree. It already contains the densest cover of trailing arbutus and colic-root I have seen in southern Michigan. The future threat to these white pines is not so much a matter of their position at the southern limit of their natural range as it is their position on the northern limit of the expanding Detroit Metropolitan area. A sign on the property reads: "For Sale."

Fig. 3. Springfield Township white pine stand, January 2, 1969; facing west on north side of fence between pasture and old field.

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Publications of Interest

From time to time we call attention, under this heading, to new publications which might be of particular interest to some of our readers but which, because of less explicit geographic or botanical orientation, do not qualify for regular review or inclusion in the listings of new literature relating to Michigan botany. All annotations are by the Editor unless ascribed to another.

MAPS OF MICHIGAN AND THE GREAT LAKES 1545 - 1845 from the private collection of Renville Wheat with additions from the Burton Historical Collection. Catalogue of an Exhibition in the Detroit Public Library October 13 to December 3, 1966. Burton Historical Collection, Detroit Public Library, 1967. 44 pp. Twelve of the 65 maps catalogued are reproduced, much reduced, and show the development of knowledge about the configuration of the Great Lakes as well as the antiquity of many place names.

THE QUATERNARY OF ILLINOIS. A Symposium in Observance of the Centennial of the University of Illinois. Edited by Robert E. Bergstrom. University of Illinois College of Agriculture Special Publ. 14. 1968. $5.00 from College of Agriculture, 123 Mumford Hall, Urbana, Ill. 61801. This volume represents prompt publication of the papers presented February 12-13, 1968, at a symposium sponsored by the University of Illinois, Illinois State Geological Survey, and Illinois State Natural History Survey. Several of the papers are on the 'Prairie Peninsula' and other biogeographical phenomena.

VASCULAR PLANTS OF OHIO. A Manual for Use in Field and Laboratory. By Clara G. Weishaupt. Revised ed. Wm. C. Brown Book Co., Dubuque, Iowa, 1968. 280 pp. $7.50. A comprehensive set of field-tested keys to the Ohio flora; no illustrations nor material on ecology or distribution. Over-priced for a paper-bound, lithoprinted volume, but should be useful in southern Michigan.

SCIENCE FOR BETTER LIVING. The Yearbook of Agriculture 1968. 386 pp. A compendium of recent research relating to agriculture, marketing, and various topics of interest to the consumer. A chapter of particular local interest on cherry harvesting has several references to the Michigan industry and cites the first mechanical tart cherry harvester, introduced in Michigan in 1959. This yearbook is available for $3.00 from the Superintendent of Documents (Washington 20402) or without charge from one's congressmen.

[More on page 107]

THE OCCURRENCE OF THE LICHEN COMPLEX, *CETRARIA CILIARIS,* IN THE STRAITS REGION OF MICHIGAN

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Investigators have long known of morphologically identical but chemically distinct strains of lichens. Well-known examples include *Cladonia chlorophaea, Parmelia cetrarioides,* and some groups in which slight differentiation may be demonstrated, as in the *Parmelia ambigua–P. hyperopta* complex, where the cortex color is different but the morphology is similar. Although Nylander's use (1866) of potassium hydroxide and calcium hypochlorite to differentiate taxa helped to strengthen the use of chemistry in the taxonomy of lichens, many lichenologists have continued to be skeptical of using chemical characters to delimit species. In recent years monographic treatments have stressed chemistry as a valid criterion in delimiting lichen taxa, but workers often remain ambivalent when chemical variation does not closely coincide with more standard characters, such as ecology, geography, morphology, etc. Our lack of understanding completely the bases of chemical variation makes most investigators very cautious of using chemical differences as the sole criterion upon which to base a taxon.

Cetraria ciliaris Ach. (*sensu lato*)[1] provides an excellent example of a species which can be subdivided geographically and chemically. Various lichen substances may be represented in the medulla in some parts of the range: protolichesterinic acid, a fatty acid; alectoronic acid, a depsidone; olivetoric and microphyllinic acids, depsides. (Depsides and depsidones are orcinol derivatives of phenylcarboxylic acids.) The microphyllinic acid population is found only on the island of Hokkaido, Japan. The other acid strains are found in North America, northern Europe, central Asia, Siberia, and Japan (Culberson and Culberson, 1967). From herbarium specimens, Hale (1963) plotted the distribution of the acid populations in the United States and Canada. He also performed field studies in the central Appalachian region, where the populations converge. Although protolichesterinic acid is present, the alectoronic and olivetoric acid populations greatly predominate in that region. In the extreme western United States the only acid found is protolichesterinic, but all three are present in the eastern United States and southeastern Canada.

In 1967, William L. and Chicita F. Culberson gave specific rank to the four chemical elements. *Cetraria ciliaris* Ach. *sensu stricto* contains olivetoric acid as a diagnostic essential; *C. orbata* (Nyl.) Fink contains protolichesterinic acid; *C. halei* Culb. & Culb. and *C. microphyllica* Culb. & Culb. contain alectoronic acid and microphyllinic acid, respectively. A complete discussion

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[1] *C. ciliaris* consists of several elements. These have been variously termed "strains" and "chemical species." As will later be shown in this paper, these elements have most recently been termed species. This work will follow that terminology, except when noted otherwise.

of the chemistry and phytogeography of these plants is in the papers of Hale and the Culbersons.

Richard Harris, of Michigan State University, introduced me to the *C. ciliaris* complex, and especially to certain questions surrounding the distribution of the acids in the lichen in the region of the University of Michigan Biological Station near Pellston, Michigan, near the Straits of Mackinac. In that summer of 1967 I became curious about ecological factors which might affect the distribution of *C. ciliaris.*

Many corticolous (bark-inhabiting) lichens have fairly specific substrate preferences. My observations were that *C. ciliaris* is essentially limited to conifers in the area of the Biological Station. Previous work has shown that the species is a pioneer, growing commonly on younger branches and high in the trees, but only occasionally on old boles. Studies of vertical distribution of cryptogams are few. Hale's earlier study (1952) was performed in a *Thuja–Acer–Betula* association; his later one (1965) in a hardwood swamp dominated by *Acer rubrum,* and the studies are not therefore necessarily comparable. In the region of the Straits of Mackinac the plants grow most commonly on *Abies balsamea* in *Thuja* swamps, on *Larix laricina* in open bogs, and on *Pinus banksiana* in the dry uplands. I have also found occasional specimens on *Acer rubrum, Alnus rugosa, Juniperus communis, Picea glauca, P. mariana, Pinus resinosa, P. strobus, Populus* sp., and *Thuja occidentalis.* Studies of herbarium labels indicate that the lichen also grows on *Betula, Malus,* and *Prunus* and is occasionally saxicolous (rock-inhabiting).

In northern Michigan, *C. ciliaris* is common enough to make sampling for the elements in this complex possible and satistically valid. I chose samples by walking in a straight to erratic manner through a stand of trees, gathering thalli at convenient heights. In areas which were difficult to move about in, fewer trees may have been sampled than in other stands, even though there may have been a tremendous number of thalli present. The sampling error in areas the size of which I studied does not exceed 5% (Hale, 1963). No trees were climbed, but treefalls were sampled when available. Approximately 200 thalli were collected in each stand. A total of 1,896 thalli were gathered in the study (cf. Table I).

METHODS OF ANALYSIS

In the summer of 1967 I used the potassium hydroxide–sodium hypochlorite (KC) test on the exposed medulla of the thallus. KC+ orange was assumed to indicate alectoronic acid, KC+ red was assumed to indicate olivetoric, and KC- was assumed to indicate protolichesterinic acid. This preliminary survey led me to believe that there was need for much more work with larger collections. In 1968 I continued with a more efficient technique. Hale (1956) had noted that lichen depsides and depsidones fluoresced under ultraviolet light (UV) supplied them at wavelengths between 3200 and 4000 angstrom units. Alectoronic acid reacts strongly under these wavelengths, fluorescing a brilliant bluish-white.

Thalli from a single gathering were spread on a black table in a darkroom and exposed to a UV lamp, and their cortices were scratched to expose the medullae. Those thalli of unquestionable fluorescence in the manner of alectoronic acid were set aside as *C. halei.* Those of absent or ambiguous fluorescence were tested microchemically as follows: Those of questionable but obvious fluorescence were checked for alectoronic acid by extracting the lichen substances with acetone on a warm microslide. GAW (1:1:1 glycerol, ethanol, and water) was used as a recrystallizing agent. The slides were warmed with the reagent and set aside until the diagnostic crystals had formed; they were then examined microscopically to determine the shape of the acid crystals which appeared. Those which did not exhibit fluorescence in UV were tested as above in GE (1:1 glycerol and acetic acid) to determine if protolichesterinic acid was present and in GAW to look for olivetoric acid. The latter were also tested with a commercial chlorine bleach (5% sodium hypochlorite) in the medullae. If they reacted C+ red, olivetoric acid was assumed to be present.

RESULTS

In the following sections, nomenclature follows that of Culberson and Culberson (1967). Table I presents an analysis of the distribution of the species on various substrata. Out of a total of 1,896 specimens, all could be referred to *C. halei* with the exception of eight *C. orbata* thalli and two of *C. ciliaris sensu stricto.*

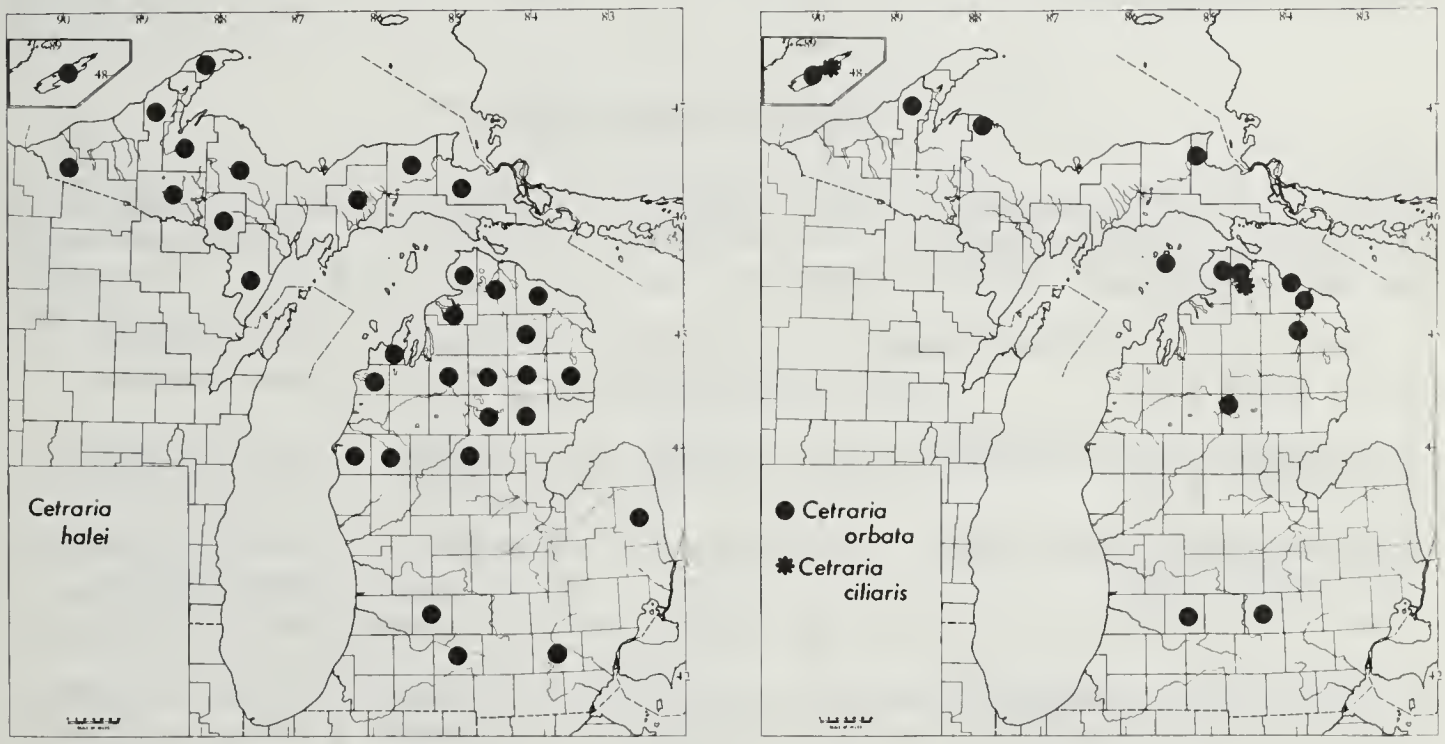

Fig. 1. The distribution of *Cetraria halei* in Michigan, showing counties from which it has been collected.

Fig. 2. The distribution of *Cetraria ciliaris sensu stricto* and *C. orbata* in Michigan, showing localities from which they have been collected.

TABLE I. Occurrence of the Species on Various Substrata.

Substratum	Number and Percentage of Thalli						
	C. halei		*C. orbata*		*C. ciliaris*		Total
Abies balsamea	319	98%	4	1.2%	2	0.6%	325
Larix laricina	454	100%	0	0%	0	0%	454
Picea mariana	431	100%	0	0%	0	0%	431
Pinus banksiana	509	99.8%	1	0.2%	0	0%	510
Unrecorded: *Abies*, *Larix*, or *Picea*	173	98%	3	2%	0	0%	176
Total	1,886	99.5%	8	0.4%	2	0.1%	1,896

Collections were made at seven localities given in Table II. The voucher specimens mentioned in the table are on file in the Lichen Herbarium of the University of Michigan Biological Station. All collection numbers are mine unless otherwise noted. (Table I does not include data from locality five below, which was sampled by a class in lichenology, because of data loss. This collection included an additional thallus of *C. ciliaris sensu stricto,* not statistically considered in Table I.)

The geographic distribution of the *Cetraria ciliaris* group in Michigan is shown in figures 1 and 2, based on data presented in this paper and from herbarium specimens at the University of Michigan (MICH) and Michigan State University (MSC).

TABLE II. Data for Voucher Collections.

Collection Area	Coll. No.	Species	Substratum
1. Cheboygan Co., Indian River, Sec. 33, T35N, R2W	L134	*C. halei*	*Pinus banksiana*
2. Cheboygan Co., Livingston Bog, Sec. 2, T36N, R3E.	L139	*C. halei*	*Larix laricina*
	s.n.	*C. halei*	*Picea mariana*
3. Cheboygan Co., Mud Lake Bog, Sec. 7, T37N, R3W.	L138	*C. halei*	*Larix laricina*
	L137	*C. halei*	*Picea mariana*
4. Cheboygan Co., Reese's Bog, Sec. 4, T36N, R3W.	s.n.	*C. halei*	*Abies balsamea*
	s.n.	*C. orbata*	*Abies balsamea*
	L140	*C. ciliaris*	*Abies balsamea*
5. Cheboygan Co., Douglas Lake, UMBS, Sec. 33, T37N, R3W.	L132	*C. halei*	*Pinus banksiana*
	L131	*C. orbata*	*Pinus banksiana*
	L130	*C. ciliaris*	*Pinus banksiana*
6. Montmorency Co., Hillman, Sec. 10, T31N, R4E.	Hale, s.n.	*C. orbata*	*Pinus banksiana*
7. Presque Isle Co., Evergreen Beach, Sec. 21, T36N, R4E.	L136	*C. halei*	Unrecorded: *Abies*,
	L135	*C. orbata*	*Larix*, or *Picea*

DISCUSSION

The species of the *C. ciliaris* complex are (seemingly) randomly scattered in all communities which occur within areas in which the species are sympatric. No differing ecological requirements have been shown to be attributable to one species or the other in this or other works. This type of investigation must be undertaken in areas in which the three species occur sympatrically, such as the region of the central Appalachians investigated by Hale in 1963. However, in his work there, *C. orbata* was represented by only 0.3% of the thalli collected (cf. 0.4% in my study near the Straits region of Michigan) and would prevent any ecological or microenvironmental study of its distribution.

In the Appalachian region the percentage of *C. halei* varied from 0 to 96, and was consistently dominant (96% to 70%) only in the shale barrens in Maryland and West Virginia (cf. Hale, 1963, esp. p. 130). In the Straits region of Michigan *C. halei* is consistently dominant, for *C. ciliaris* represents no more than 0.1% of the population. *C. orbata* is represented by approximately the same percentage in both regions.

The thalli of these species produce no effective vegetative propagules, such as isidia or soredia, and the diaspores are the fungal ascospores and conidia. The predominant means of dispersal of this species is probably by means of ascospores. If this is so, the distribution of these species may be a reflection of physiological and genetical differences acting upon or with the environment. On the other hand, the little investigated, but important effects of pleiotropy (the control of several paths of development by one gene, or of several phenotypes by one gene) must receive more consideration in what we call "chemical taxonomy" in any group of plants.

ACKNOWLEDGMENTS

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SYSTEMATIC AND ECOLOGICAL STUDIES ON *PLANTAGO CORDATA*

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The genus *Plantago* L., consisting of 250-275 species, is represented by one or more species in most parts of the temperate regions of the world. Although *Plantago* is often considered a weedy genus, in reference to such "camp-followers" as the common plantains, *P. major* L. and *P. lanceolata* L., in reality over 90% of the species are of restricted distribution. Some species, such as the four which occur only at the summit of Mt. Waialeale, Hawaii, are endemic to very small areas and are highly specialized ecologically. Other species have broader geographical ranges but are not common anywhere. *Plantago cordata* Lam. is in the latter category and is surely the rarest of the North American plantagoes.

My study of *P. cordata* was made in connection with a long-range study of the broad evolutionary relationships of the genus *Plantago.* Pilger's (1937) monograph of the Plantaginaceae recognized 19 sections in *Plantago.* The section *Paleopsyllium,* in which he included *P. cordata,* was considered a natural group and the least specialized of the genus. My own studies indicate, however, that *Paleopsyllium* is actually a potpourri of quite unrelated and specialized species. In reviewing this and the other taxonomic sections as used by Pilger, I have tried to obtain living material of as many species as possible. The first population of *P. cordata* was not found until a year after I had begun an intensive search for the species. The difficulty in locating extant populations and the apparently subtle ecological requirements of *P. cordata* under natural conditions posed several problems which this paper attempts to resolve. The rarity of the species, and perhaps its imminent extinction, call for a thorough study of it at this time.

MATERIALS AND METHODS

Living plants were obtained from the following stations: (1) Plum Run Quarry, 2 mi E of Peebles, Adams Co., Ohio (*Tessene 1881*); (2) Farm of Mr. Harvey Lockney, ca. 1.5 mi NW of Thedford, Bosanquet twp., Lambton Co., Ontario (*Tessene 1941*); (3) Stockport Landing, Columbia Co., N. Y. (*Tessene 2065*); (4) Small stream leading into NE side of Lake Murphysboro, Jackson Co., Ill. (*Tessene 2066*); (5) 3 mi NW of Denton, Flat Swamp Creek, Davidson Co., N. C. (*Stephenson 618*); (6) Chekomeko Creek, Columbia Co., N. Y. (*Hines 6825*); (7) Messenger Woods, 2 mi N of New Lenox, Willis Co., Ill. (*Tessene 2176*). Seeds were supplied by Dr. I. John Bassett from 3 mi W of Millcreek, Madison Co., Mo. (*Bassett & Spicer 4501*). All specimens were planted in pots and grown under uniform conditions at the University of Michigan Botanical Gardens. These plants served as stock cultures for the

ecological and systematic studies. Field observations and ecological data were recorded in the field at the time of collection. In addition, specimens from a number of herbaria were examined. Standard techniques were used in the cytological and histological studies.

Voucher specimens for chromosome counts, morphological variation, and drawings will be deposited in the Herbarium of the University of Michigan (MICH).

DESCRIPTION OF THE SPECIES

Plantago cordata was originally described by Lamarck in 1791 from material at the Jardin Botanique in Paris grown from seeds attributed only to "Canada." The type specimen (P, photo MO! DAO) is unfortunately a mixture of the leaves of *P. cordata* and the spike of *P. major.* Although the mixed collection was probably an accident, the two species are often confused especially in the vegetative state. The superficial resemblance of the large, expanded phyllodes of *P. cordata, P. major*, and *P. rugelii* (Fig. 1) may lead the casual observer to believe the three species are closely related. However, the gross morphology and the anatomy of the flowers and seeds do not support this hypothesis. The specialized fleshy roots and usually hollow mature peduncle of *P. cordata*, as well as its phenology and its ecology, show it to be the most divergent of the three species and at most, only distantly related. The following key will distinguish *P. cordata* from other broad-leaved species of the genus in Eastern North America.

1. Leaves cordate to broadly elliptic, with petiole and blade clearly differentiated; sepals and bracts glabrous
   2. Major roots massive and fleshy, 0.5-1.3 cm in diameter; peduncle 3-4 mm thick, with a central cavity usually present and equalling 3/4 or more of total diameter; seeds 2 (-4) per capsule; major veins of leaf not parallel to margin, appearing to arise from "mid-rib"; leaves leathery . . . . . *P. cordata*
   2. Major roots cord-like to filamentous, 0.1-0.3 cm in diameter; peduncle 1-2 mm thick, with central cavity, if present, less than 1/3 of total diameter; seeds 4-12 per capsule; major veins of leaf parallel to margin; leaves thin
      3. Capsules oblong, dehiscing near base; seeds black, 4-9 per capsule; bracts and sepals lanceolate-attenuate; leaves broadly elliptic, the margins bearing 3-7 small teeth, glabrous . . . . . *P. rugelii*
      3. Capsules rhombic-ovate, dehiscing medially; seeds brown, 8-12 per capsule; bracts and sepals ovate-obtuse; leaves cordate-ovate, the margins entire, glabrate or hirsutulous . . . . . *P. major*
1. Leaves spatulate to linear, with petiole and blade poorly if at all differentiated; sepals and/or bracts usually pubescent
   4. Leaves glaucous, glabrous, erect; roots fleshy; bracts and sepals ovate-obtuse . . . . . *P. eriopoda*
   4. Leaves not glaucous, hirsutulous; roots thin; bracts and sepals lanceolate-attenuate . . . . . *P. media*

Plantago cordata Lam. Tabl. Encycl. Méth. 1: 338. 1791.
P. kentuckensis Michx. Fl. Bor.-Am. 1: 94. 1803.
P. multiplinervia Steud. Flora 32: 410. 1849.

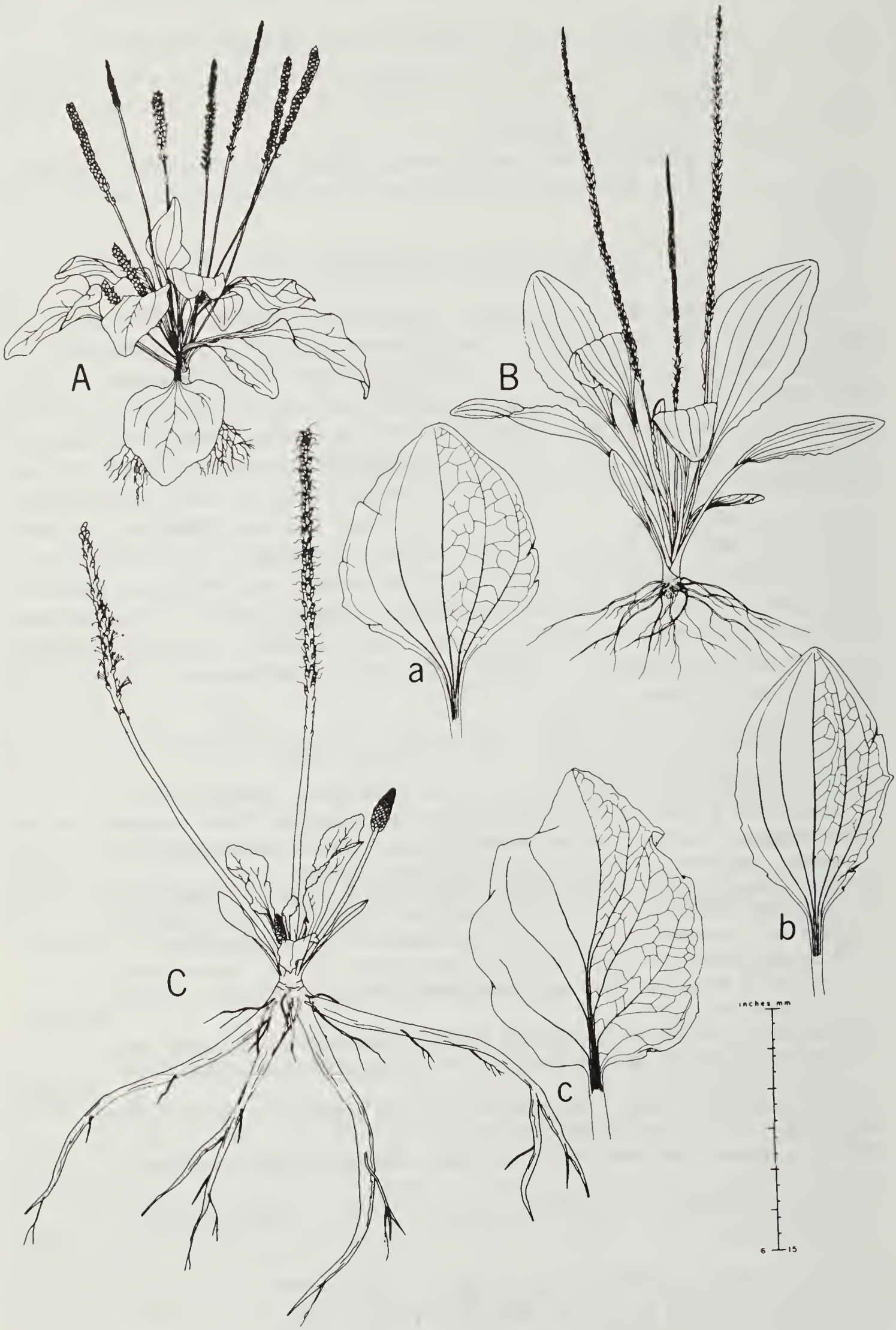

Fig. 1. Habit drawings of *Plantago cordata* and superficially similar species. A) *P. major*; B) *P. rugelii*; C) *P. cordata*; a,b,c) Leaves of respective species.

Plants herbaceous perennials. Major roots massive and fleshy, branching several times, 0.5-1.3 cm thick. Minor roots sparse, fibrous. Leaves (Fig. 2) in winter rosette broadly spatulate-acuminate, 1-3 cm wide; in late spring and summer cordate-ovate but never truly cordate, 8-19 cm wide, 12-23 (-50) cm long;

Fig. 2. Silhouettes of *Plantago cordata* leaves collected Sept. 15, 1967, at Stockport Landing, N.Y. The largest leaf drawn is 7 inches wide.

major veins (3) 5,7 (9), not parallel to margin, appearing to arise from a "midrib" 1/3-1/2 of the way from the base of the blade; margin entire or undulate; lamina with a leathery texture, frequently drying black or dark-brown; petiole base often purple. Inflorescence a spike, its total length including peduncle 12-60 cm, glabrous; a central cavity usually present and equalling 2/3 of total diameter of peduncle; flowers 2-4 per cm at center of spike, becoming scattered at basal and distal ends of inflorescence. Flowers (Fig. 8) perfect, protogynous, obovate in outline; sepals 4, free and distinct, 2-2.3 mm long; bract solitary, glabrous, resembling sepals, obovate, pigmented central area bordered by a very narrow hyaline margin, tip truncate; petals 4, connate basally, lobes 2-3 mm long, deltoid, chartaceous, light brown, appressed to sepals at anthesis; stamens 4, epipetalous, filaments 0.9-2.3 cm long; anthers versatile, pale yellow and/or purple, horned at basal end, pollen copious; gynoecium superior, bicarpellate; stigma with two parallel rows of hairs extending from below corolla to slightly bifid tip. Capsule (Fig. 3) a pyxis, ovate, 9-11 mm long, circumscissile sub-medially, often retaining old corolla when mature. Seeds (Fig. 3) 2 (rarely 3-4) per capsule, 3-3.8 mm long, tan-brown; testa smooth, mucilaginous covering heavy, planar area conspicuous on one end of seed, obscured on the other; hilum and micropyle separated.

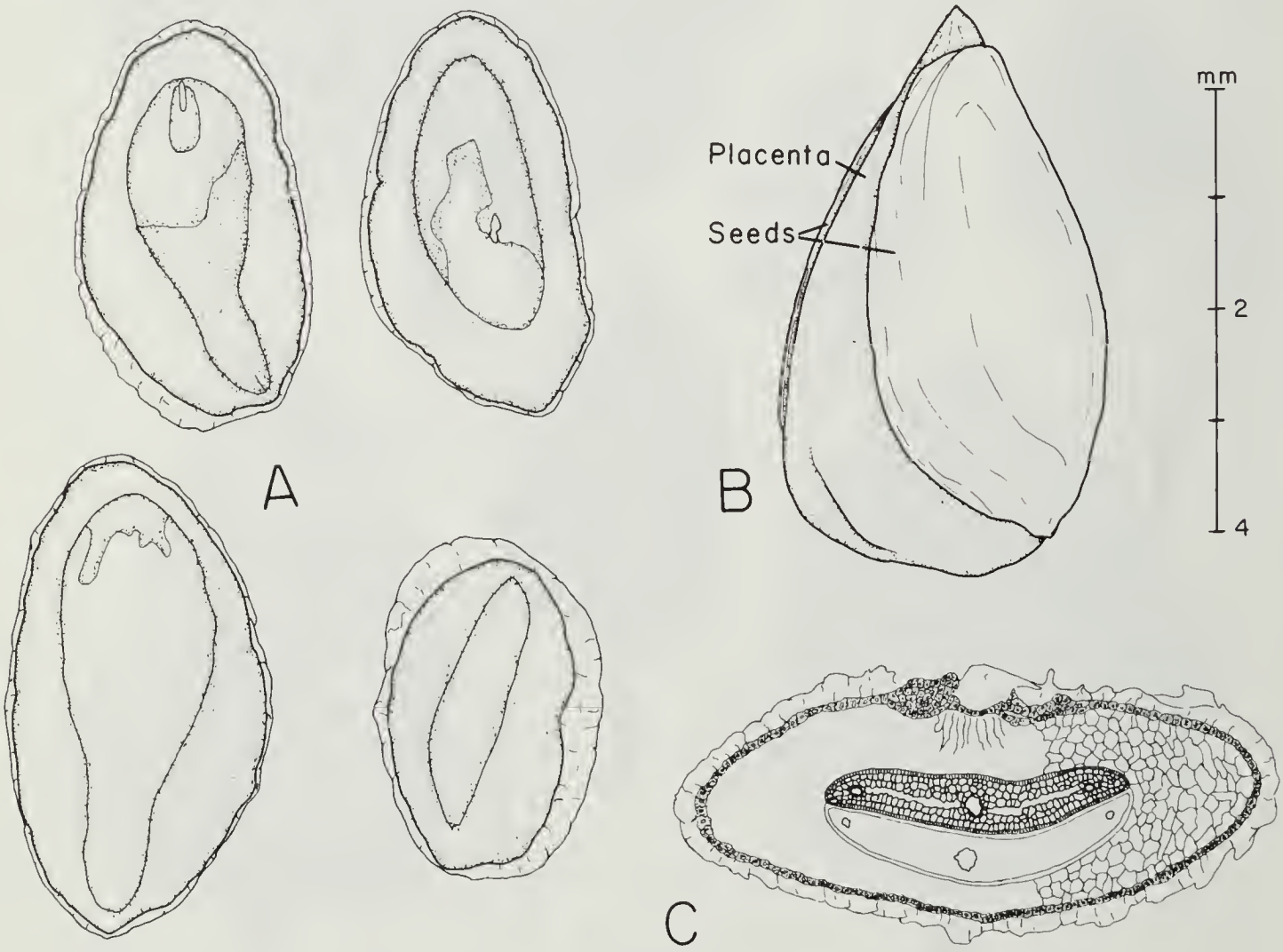

Fig. 3. Reproductive structures of *Plantago cordata*. A) Seeds; B) Seeds connected to placental septum as shed from capsule; C) Medial cross-section of seed (drawn to slightly larger scale).

LEAVES

Most manuals and floras which include *P. cordata* (e.g. Small, 1933; Fernald, 1950; Gleason, 1952; McVaugh, 1958; Fassett, 1959; Gleason & Cronquist, 1963; Steyermark, 1963) distinguish it from other members of the genus by the venation of the leaf. In *P. cordata,* lateral veins supposedly arise from a midvein or midrib rather than from the base of the leaf as is more common in the genus. Although the false midrib is present in many mature specimens of *P. cordata* (Figs. 1, 4, & 10), it is not invariably present nor, on any individual plant, is it present on all leaves or at all times of the year. The emphasis on this character is particularly unfortunate as the "midribbed" leaf usually does not develop until after the plant has finished flowering and fruiting. Therefore, at certain times, specimens of *P. cordata* are identifiable to genus but the keys will not always clearly distinguish the species. This confusion is, perhaps, one reason why *P. cordata* has been questioned as a "good species" by those who have never seen it and why it may be overlooked or ignored by collectors in the late spring and summer.

The mature summer leaves of *P. cordata, P. macrocarpa* of the Pacific Northwest and the *P. princeps* complex of the Hawaiian Islands are highly specialized and are the most extreme examples of a pseudolamina (*sensu* Arber, 1918) in the genus. The mature leaves of *P. cordata* are very similar to the basal leaves of *Mertensia virginica* and sterile specimens of the two species may be confused.

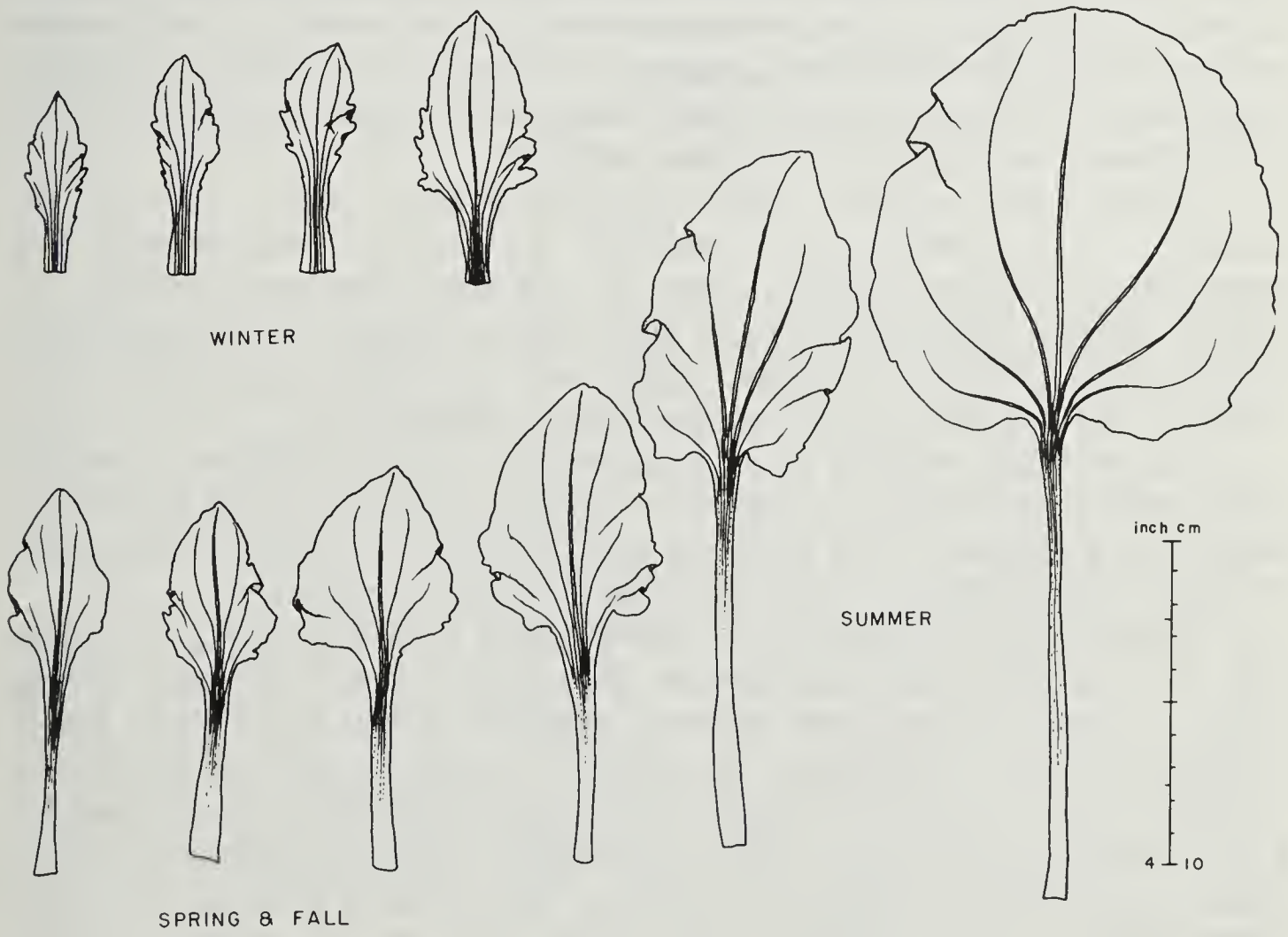

Fig. 4. Seasonal heteroblastic leaf sequence in *Plantago cordata.*

The leaves of the winter rosette of *P. cordata* (Figs. 1 & 4) are lanceolate to spatulate and usually parallel-veined. In the spring, a heteroblastic sequence terminates in a more or less "midribbed" leaf. The sequence may be interrupted and arrested at any stage. An interruption is readily brought on by stress conditions, e.g. drought, prolonged periods of direct sunlight, or high temperatures. If the sequence is not interrupted, three or four summer leaves will be produced before the reverse sequence in the fall again results in leaves of the winter rosette type. In the greenhouse, many plants flower, fruit, and subsequently slough off the peduncles, thus initiating what is, in the field, the summer stage; but they never develop leaves beyond those of the spring type. Completion of the cycle is apparently under environmental control as the same plants will, under other conditions, progress through the complete series. If the plants are grown continuously, without being subjected to a cold treatment, and under a 12-hour or longer day, the rosette will consist only of summer leaves. I have experimentally held plants at this stage for over a year. However, either short days (eight hours) or a cold treatment will initiate a reversal to the winter rosette. Plants in the winter rosette, even when held under short days and/or cool (50° F) storage, will, if the temperature is above freezing, spontaneously initiate spring leaves and inflorescences after about a month. However, they will not produce summer leaf types under these conditions.

Leaf shape and size vary considerably within any population, in addition to the variation associated with the heteroblastic development. Fig. 2 shows the variation in shape and maximum size of summer leaves collected September 15, 1967, at the Stockport Landing, N. Y., station. In general, the largest leaves were from plants in more shady habitats; the smallest leaves were from plants growing on a gravel bar in direct sunlight.

Petiole length and leaf width, at any heteroblastic stage, also vary considerably and are under direct influence of light intensity, available water, and temperature. Low light intensity, wet soil, and low temperatures result in the longest petioles and widest leaves. High light intensity, dry soil, and high temperatures result in the shortest petioles and narrowest leaves. Various combinations of these factors result in intermediate proportions.

The variation resulting from the interplay of the heteroblastic series and environmental conditions is expressed in all the populations, both in the field and in the greenhouse. This plasticity must be kept in mind when looking for the plant in the field and when identifying herbarium specimens.

Anatomically, the leaves of *P. cordata* show little variation. The leathery leaf texture, typical of this species, is the result of a well developed spongy mesophyll and, in some cases, an aerenchyma-like tissue. This is most highly developed in plants growing in the open sun in the water and results in a "flabby" or almost succulent leaf texture. In cross-section, the leaf shows a palisade layer on both the adaxial and abaxial sides. The epidermal patterns (Fig. 5) are similar on both leaf surfaces. The scattered stomata are usually surrounded by four auxiliary cells having more or less sinuate margins. The simple, 2-celled, capitate hairs have a single stalk cell and are of sporadic

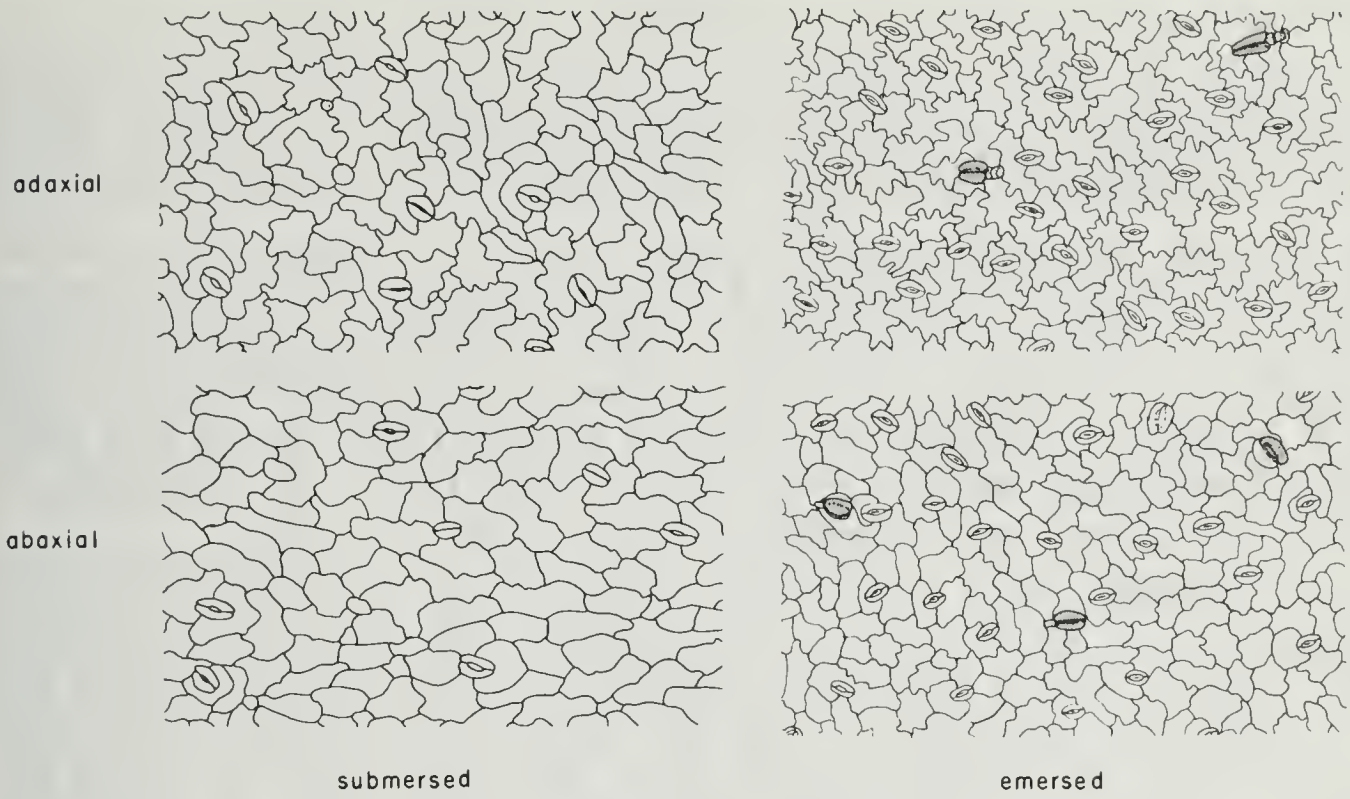

Fig. 5. Epidermal cells on leaves of *Plantago cordata.*

occurrence on emersed leaves. The plant appears glabrous to the naked eye.

Leaves produced on submersed plants have generally larger epidermal cells with only slightly sinuate margins (Fig. 5). Stomata are present but they are not so abundant as on emersed leaves; and abortive stomatal mother cells which did not undergo further development are common. The latter may be recognized in Fig. 5 by the radially arranged auxiliary cells. No hairs are present on submersed leaves although a few specialized epidermal cells resembling trichome bases are found on the adaxial surface.

STEM

The stem of *P. cordata* is a short fleshy caudex, 2-4 cm in diameter and 1-3 cm high. This caudex consists of the true stem (a corm) and the greatly swollen, persistent hypocotyl. The upper portion is covered with numerous adjacent leaf scars. It is glabrous except at the bases of the current leaves and at the apical region where a silky tomentum of hyaline hairs 1 cm or less long, covers the meristematic regions. The older portions of the stem become covered with a spongy endodermis which merges into the fleshy root cortex.

There is no evidence of internodal elongation. The approximate age of a plant may be estimated by counting the spiralling ridges formed by the leaf scars. The broader leaf scars formed by the summer leaves alternate with the narrow ridges formed by the winter leaf bases. Lateral buds, which may occur sporadically on older specimens, give rise to small rosettes. If these become detached through mechanical injury or sloughed off from a dying parental stem, they will reproduce the plant vegetatively. I have not observed the lateral shoots producing inflorescences while attached to the main parental stem.

ROOT

The root is the most characteristic morphological feature of *P. cordata.* The genus *Plantago* has both of the two basic types of root systems: tap and fibrous. Most sections (*sensu* Pilger, 1937) contain species showing both types. The tap root is usually correlated with annual or biennial life cycles (*P. macrocarpa* which is a perennial is a notable exception). In those species with a fibrous root system, e.g., *P. major* and *P. rugelii,* the roots are relatively narrow and the primary food storage organ is the caudex. *Plantago cordata* and *P. eriopoda* are unusual in *Plantago* in having a fleshy fibrous root system which serves as the primary food storage organ (Figs. 1 & 7). Likewise the development of the roots is unusual in these species.

In *Plantago,* as in most dicotyledonous angiosperms, the radicle is the primary root. In species with a tap root system, the major root develops directly from the radicle and can be considered a developmental extension of it. The fibrous root system differs from this basic plan in that the primary root soon dies or its development is determinate, whereupon numerous lateral roots develop. In most *Plantago* species with a fibrous root system, the lateral roots either arise from this much shortened primary root (e.g., *P. indica*) or, in most perennial species having a caudex, the lateral roots arise adventitiously from the caudex (e.g., *P. lanceolata*). However, *P. cordata* and *P. eriopoda* produce fibrous roots not as laterals from the primary root nor from the caudex, but adventitiously from the persistent hypocotyl, as shown in Fig. 6. In these species, the primary root derived from the radicle is short and withers soon after the adventitious roots are initiated. The lateral roots are also limited in development, averaging 8-10 cm in length. After maximum length is reached, these become thickened and, in turn, give rise to tertiary roots which likewise become thickened, and so on. Since the length of each root is finite, the axis of a lateral root system is usually zigzagged. In cases where a secondary or

Fig. 6. Seedling development in garden-grown *Plantago cordata.*

tertiary root happens to become aligned, by overtopping, on the same axis as the root from which it arose, a definite constriction indicates the point of origin of the new root. Scattered across the entire root system, but concentrated at the distal ends, are small thread-like roots bearing very few, if any, root hairs.

The large fleshy roots of *P. cordata* and particularly the seemingly continuous texture of the roots, hypocotyl, and caudex have led to some confusion in the literature. Tyler (1901) interpreted the large root as part of a rhizome which had rotted out in the center and had subsequently broken up. His photograph of this condition actually shows a lateral shoot which apparently was torn from the original plant along with one large fleshy root. (The herbarium specimen from which the photograph was made is *F. J. Tyler,* October 2, 1901, OS). An old plant can have a hollow caudex and, if the apex dies, it is easy to see how a lateral shoot could become an independent plant. It is sometimes difficult to distinguish between a fleshy root and a caudex on herbarium specimens. This lack of differentiation between the caudex and the large storage roots could easily lead to their misinterpretation as a rhizome.

Anatomically the roots of *P. cordata* have several modifications reflecting its aquatic habitat. The highly developed cortex containing abundant aerenchyma (Fig. 7), the paucity of root hairs, and the production of adventitious roots are all characteristic of aquatic plants (Esau, 1953). The root cortex is the important storage tissue in *P. cordata.* The cells are frequently filled with starch grains which may be single or in groups of 2-4 (Fig. 7). These are the largest starch grains of the 97 species of *Plantago* I have observed to date.

REPRODUCTIVE BIOLOGY

PHENOLOGY

Plantago cordata is a short-day plant. Initial blooming may begin in March in the south (Harper, 1944; Godfrey, 1960) and in mid-April in the north. Rarely the plant will bloom again in September and October. Although

Fig. 7. Left: Photomicrograph of cross section of a root of *Plantago cordata.* Right: Starch grains from cortex of root (drawn from projected image).

anthesis takes place normally in the spring, the young inflorescences are initiated in the fall. These young spikes are well protected throughout the winter by the imbricate petiole bases. Following a cold treatment, which may consist of simply an early frost, the peduncles elongate and the plant blooms. There is no evidence that the fall-blooming plants set seed. Even if they did, the resulting seeds would not have time to germinate and become established before winter set in. Thus the reproductive potential of the plant for the following season would be lost (cf. below, "Life History").

INFLORESCENCES

Under field conditions, inflorescences are subtended only by leaves in the winter or the spring and fall condition (Figs. 1C & 4) although summer leaves may be present on the plant. Therefore, the number of inflorescences (averaging six per plant) is partially determined by the duration of the cool fall season and/or the first frost. In the greenhouse, individual plants have sporadically produced inflorescences in the axes of summer leaves when the plants have been maintained under extended (10 months) summer conditions.

In the spring, the young inflorescences grow up beyond the protecting petioles and the leaf blades, through the activity of an intercalary meristem. Under cool, moist conditions, the peduncle grows to a length of 15-30 cm in 6-7 days. Simultaneously, the flowers are maturing and meiosis occurs. Approximately one week after growth begins, the peduncle reaches its maximum length and the stigmas of the lowest flowers are extended. At this time, the meristematic activity shifts to the rachis. Beginning at the bottom of the spike and progressing upward, the elongation of the rachis coincides approximately with the extension of the stigmas of the flowers. Three to four days after the extension of the stigma, the individual flowers protrude their stamens. This sequence progresses acropetally. The processes of stigma extension, elongation of the rachis, protrusion of anthers, and, to a small extent, initiation of additional flowers at the tip of the spike, continue (under favorable conditions) for a period of one and one-half to two weeks, at which time an inflorescence totalling 40-60 cm in length and bearing 80-130 flowers is produced. If environmental conditions are usually dry, elongation of both the peduncle and the rachis is inhibited and frequently the terminal portion of the inflorescence aborts, resulting in a depauperate inflorescence. This condition is frequently observed on herbarium specimens.

The young inflorescences, up to the time of anther protrusion and the beginning of seed set, are soft, brittle, and solid. As the capsules start to develop, the peduncle becomes hard, tough, and hollow. Depauperate inflorescences often retain solid peduncles, so peduncle hollowness should be used with caution as a diagnostic characteristic of this species.

In contrast to most *Plantago* species, the peduncle and rachis of *P. cordata* remain alive through the time of capsule dehiscence.

FLOWERS, FRUIT, AND SEEDS

The flowers of *P. cordata* (Fig. 8) are typical of the genus. They are well adapted to wind pollination as shown by the reduced, chartaceous

corolla, the long, plumose stigma, and the versatile anthers bearing copious pollen. For a comparative description of the morphology of the pollen, see Bassett (1968). Each flower is subtended by a green, oval, glabrous bract. The bracts beneath the lowest flowers of the spike may be enlarged and leaf-like,

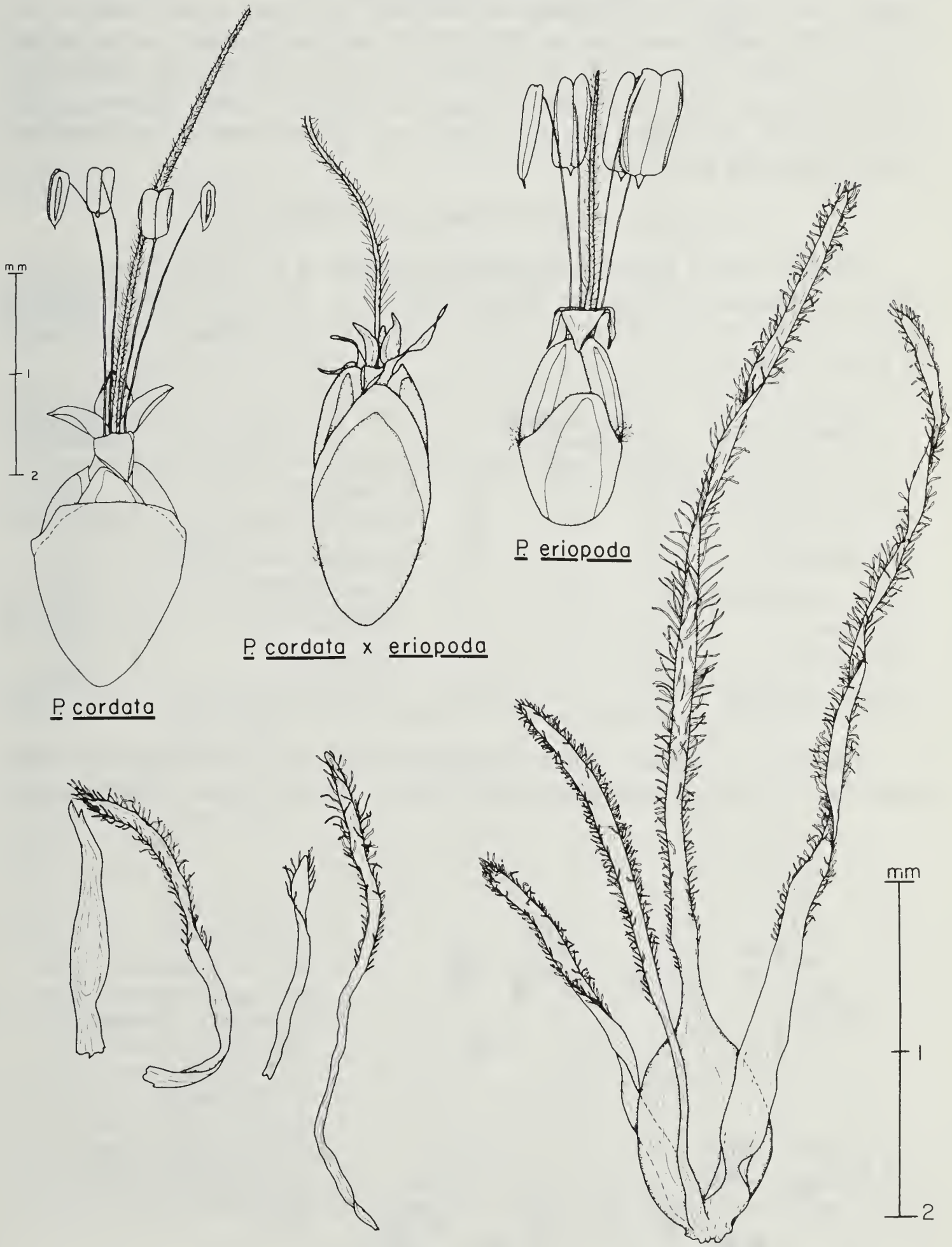

Fig. 8. Flowers of *Plantago cordata, P. eriopoda,* and hybrid. Abnormal gynoecial parts of *P. cordata* x *eriopoda.*

often obscuring the included flower. No floral abnormalities have been observed in this species.

The gynoecium, at the time of anthesis, contains four ovules although usually only two or three seeds are produced per capsule. The capsules of *P. cordata* are unique in the genus in that they are alive at the time of dehiscence. The abscission layer of the pyxis is well developed even before the seeds are mature. The top of the capsule is usually held on only by the connecting septum. When the seeds are ripe, the capsule readily dehisces at the slightest touch. The seeds and the entire fleshy placenta fall out as a unit, an unusual character in the genus.

CYTOLOGY AND HYBRIDIZATION EXPERIMENTS

Bassett (1967) reported chromosome counts of *P. cordata* from a population in Missouri and one in North Carolina as 2n = 24. I have observed meiotic figures (Fig. 9) from the following populations. Meiosis was normal in all plants observed.

Collecting Site	No. of plants observed	Collection	Bivalents at Meiosis
Ill., Lake Murphysboro	2	*Tessene 2066*	12
Ill., New Lenox	2	*Tessene 2176*	12
Mo., Millcreek	1	*Bassett & Spicer 4501*	12
N.Y., Stockport Landing	5	*Tessene 2065*	12
N.C., Denton	1	*Stephenson 618*	12
Ohio, Peebles	5	*Tessene 1881*	12
Ontario, Thedford	5	*Tessene 1941*	12

Plants of *P. cordata* are self-compatible but some outcrossing is facilitated by the protogynous development of the flowers. Once pollination and

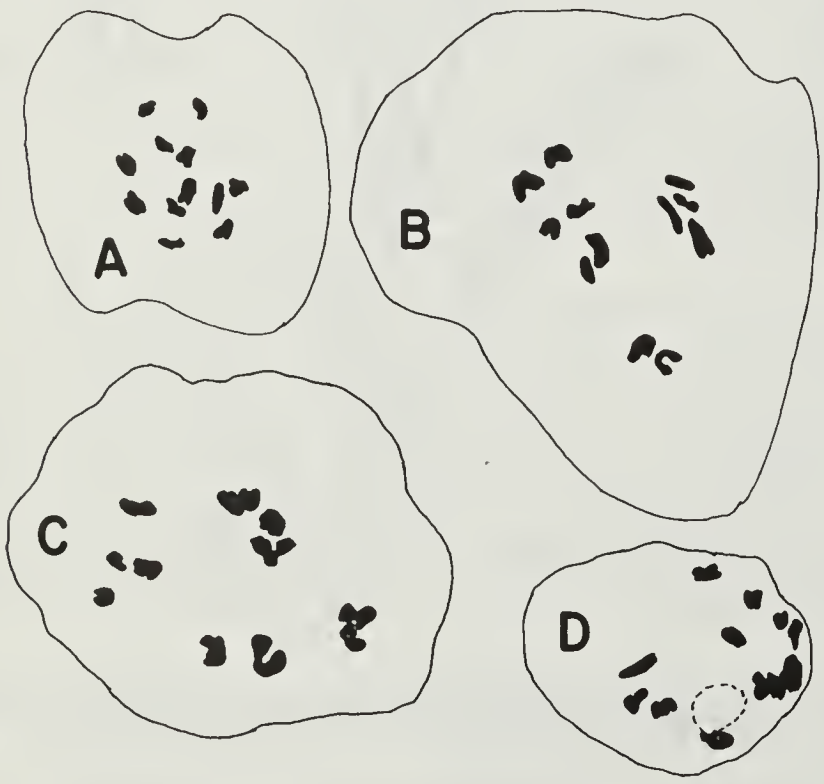

Fig. 9. Camera lucida drawings of meiotic chromosomes of *Plantago cordata:* N = 12 in all cases. A) Hudson River, New York (*Tessene 2065*); B) Peebles, Ohio (*Tessene 1881*); C) Thedford, Ontario (*Tessene 1941*); D) New Lenox, Ill. (*Tessene 2176*).

TABLE I. Hybridization experiments involving *Plantago cordata.*

Female Parent	Male Parent	No. of spikes pollinated	No. of seeds set	No. of F_1 plants	F_1 pollen stainability	Comments
P. cordata Peebles, Ohio	*P. eriopoda* Wyo. (n=12)	3	10	1	3%	See text
P. eriopoda Centennial, Wyo.	*P. cordata* Thedford, Ont.	4	6	-	-	-
P. cordata Peebles, Ohio	*P. cornuti* Bot. Gard. Coimbra, Portugal. (n=6)	3	2	-	-	-
P. cordata Thedford, Ontario	*P. reniformis* Bot. Gard. Coimbra, Portugal. (n=6)	2	-	-	-	-
P. rugelii (n=12) Ann Arbor, Mich.	*P. cordata* Stockport Landing, N.Y.	6	4	-	-	Seeds abortive
P. cordata Peebles, Ohio	*P. rugelii* Ann Arbor, Mich.	2	-	-	-	-
P. cordata Stockport Landing, N.Y.	*P. media* (n=12) Berlin, Germany	3	-	-	-	-
P. cordata Peebles, Ohio	*P. pachyphylla* v. *montis-eekis* Maui, Hawaii (n=12)	3	6	-	-	-
P. pachyphylla v. *montis-eekis* Maui, Hawaii	*P. cordata* Peebles, Ohio	2	-	-	-	-
P. cordata Peebles, Ohio	*P. princeps* Maui, Hawaii (n=6)	4	-	-	-	-
P. princeps Maui, Hawaii	*P. cordata* Stockport Landing, N.Y.	3	3	-	-	Seeds abortive
P. cordata Peebles, Ohio	*P. sparsiflora* Allenhurst, Geo.	6	-	-	-	-
P. sparsiflora Allanhurst, Geo.	*P. cordata* Peebles, Ohio	4	2	-	-	No seed germination

germination of the pollen grain has occurred, the stigma rapidly withers and dries—often before the particular flower protrudes its stamens. The lowest flowers have a high probability of setting seed via outcrossing, but flowers on the upper portion of the spike may well be fertilized by pollen arising from the lower flowers. All my greenhouse populations of *P. cordata,* except *Hines 6825*, have been intercrossed and are completely interfertile.

The protogynous condition and rapid withering of the pollinated stigma make *Plantago* an excellent group with which to perform hybridization studies. If the experimental plants are isolated (either mechanically or spatially) and pollinated as soon as the stigmas appear, self-fertilization is almost completely eliminated. Utilizing an aluminum foil jacket to isolate the young spikes, I made a series of controlled crosses to determine the degree of promiscuity of *P. cordata.* The results are presented in Table I.

As can be observed in Table I, *P. cordata* apparently does not readily hybridize with the species listed. The one hybrid plant obtained, *P. cordata* × *eriopoda* (Figs. 8, 10, & 11), is intermediate between the parents in most characters (Figs. 8 & 10). The hybrid is sterile, having abortive, non-emergent anthers, less than 5% pollen stainability, and, occasionally, extra gynoecial parts which are abortive (Fig. 8).

Structural abnormalities of the androecium are common in *Plantago* hybrids (Hope-Simpson, 1939; Rahn, 1956; Gorenflote, 1959, 1961; Cartier, 1963; Stebbins & Day, 1967); however, the only abnormalities of the gynoecium which have been reported have been induced by herbicides (Hitchcock & Zimmerman, 1947) or were spontaneous (Gorenflote, 1959). Gorenflote also reported teratological gynoecia in hybrids of *P. coronopus* and *P. maritima* but these did not include supernumerary parts. What, if any, evolutionary significance there may be in the occurrence of unusual gynoecia in *P. cordata* × *eriopoda* will not be discussed here.

LIFE HISTORY

Plantago cordata is readily grown under standard greenhouse conditions in a 2:1 mixture of rich loam and sand and without need for flooding. Although flooding more closely approximates the aquatic conditions under which the plants grow in the field, I have found no need to endeavor to simulate natural conditions in the greenhouse. The plants require frequent watering, and I have grown them in flooded pots.

The seeds and seedlings are apparently the most critical stages in the life of *P. cordata.* As indicated above, the seeds remain attached to the spongy placenta (Fig. 3) when first shed. The resulting unit is highly buoyant and rapidly disperses the seeds if it happens to fall in the water. When the seeds come in contact with the water, the hygroscopic mucilaginous coat surrounding them swells, eventually forcing the seed away from the placenta and breaking the funiculus. Once freed, the seeds float individually with their planar surfaces upward. The mucilaginous coating causes a seed to adhere to any object which it contacts in the water. The seeds will germinate after 6-14 days even if they are still floating, but will not germinate under water. The

seedlings will continue to float for another week before eventually sinking and dying. It is during this critical three-week period of seed dispersal and establishment that the reproductive potential of *P. cordata* is realized. If the seed or a floating seedling does not become established in a favorable location, it is lost. Longevity experiments show that the seeds must germinate rapidly, as they live only about a month in storage at 40°F. (It is interesting to speculate on how the seeds yielding the type of *P. cordata* ever got to Paris and still managed to germinate.)

If a plant becomes established, it will bloom the following year. The

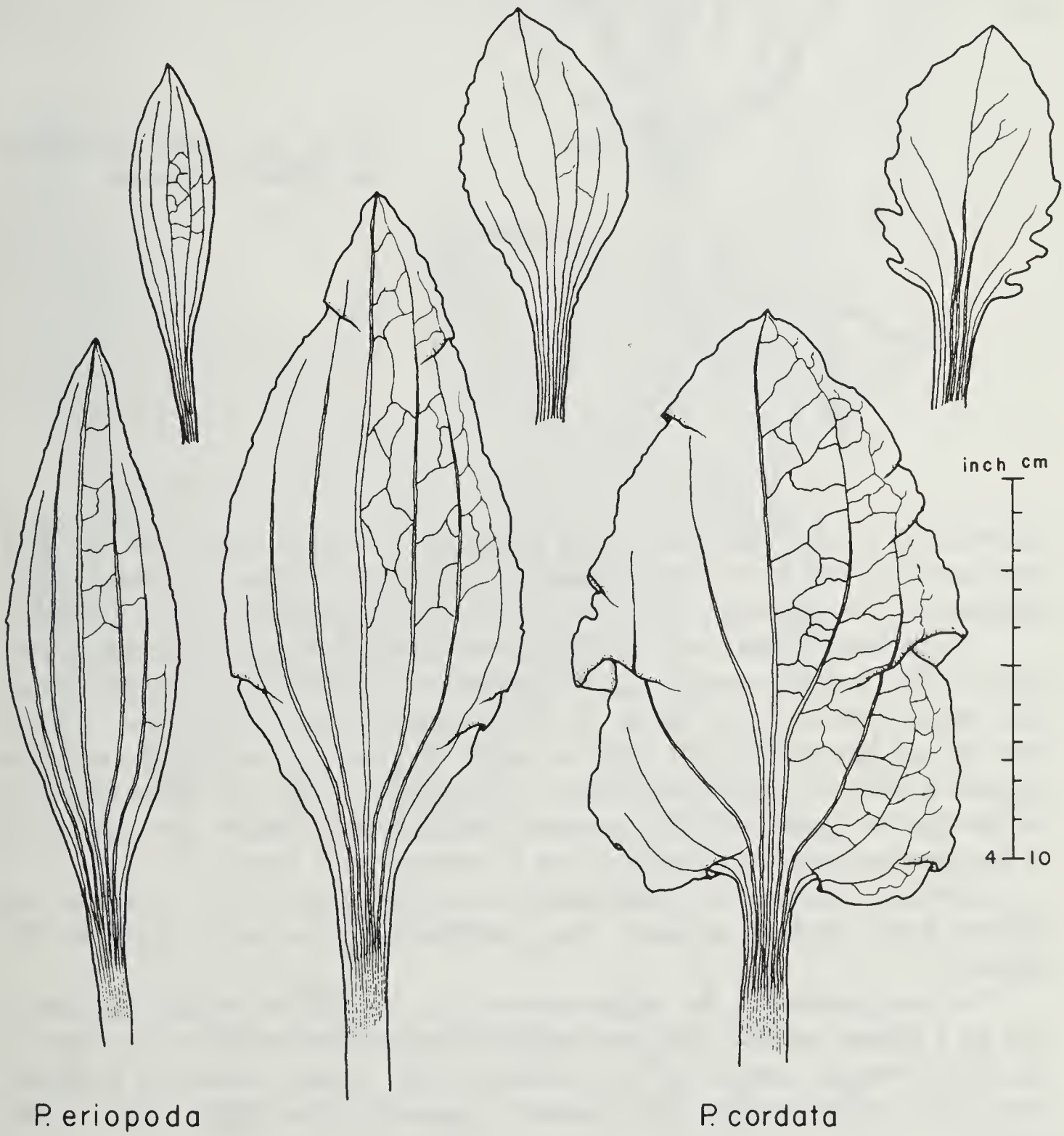

Fig. 10. Leaves of *Plantago cordata, P. eriopoda,* and hybrid.

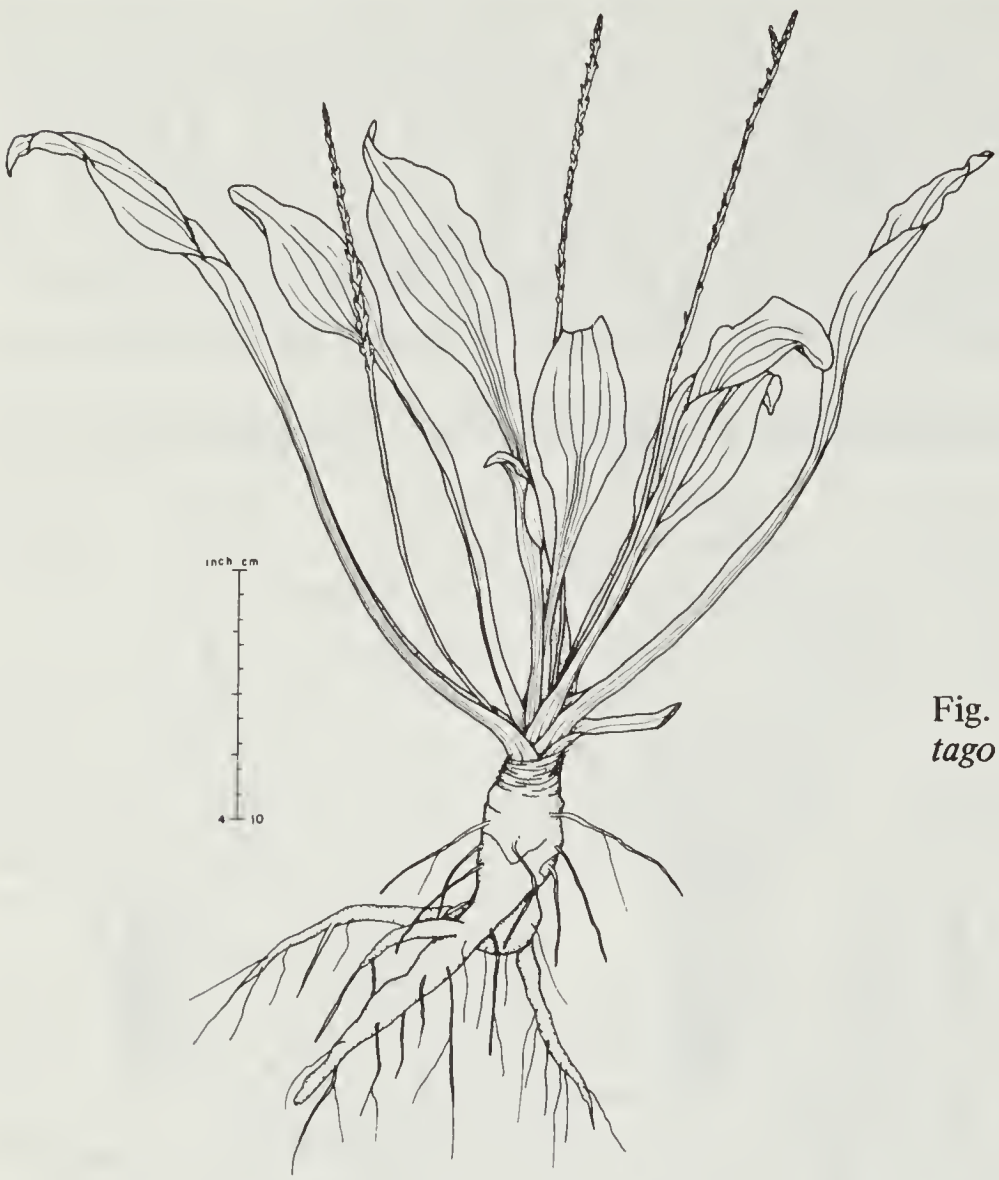

Fig. 11. The hybrid plant, *Plantago cordata* x *eriopoda.*

longevity of plants is not known but I have kept mature plants from the field alive and vigorous in the greenhouse for three years. These specimens were estimated to be approximately four years old at the time they were collected.

From field observations and herbarium specimens, it appears that *P. cordata* has few natural enemies. Close observation of most collections will reveal 5-10 small cysts 1-2 mm across on one or more leaves. The cause of these cysts is not known but the lack of fungal hyphae or insect larvae suggests perhaps a virus or bacterium. Plants bearing these cysts have been grown in culture for two years with no apparent deterioration. Similar cysts are found on many other species of *Plantago,* e.g. *P. lanceolata, P. rugelii.*

Dodder, *Cuscuta* sp., was found on several plants of *P. cordata* at the Hudson River station; however, this resulted in no noticeable harm to the plantago.

In the greenhouse, the inflorescences of *P. cordata* are subject to infestation by a downy mildew. The same mildew (species unknown) attacks most of the 103 *Plantago* species in my collection but usually grows on both the leaves and inflorescences. The mildew apparently does little harm to the plants.

Insect damage is also rare. Three specimens (all from Illinois) have "nibblings" along the margin of the leaf suggesting the activity of leaf-cutting wasps. In the greenhouse, red spider mites often feed upon the inflorescences

of *P. cordata.* The silky threads left by the mites may inhibit the full protrusion of the stamens. This infestation has not been observed in the field.

DISTRIBUTION AND ECOLOGY

The geographical distribution of *P. cordata* (Fig. 12) is correlated with the occurrence of limestone and dolomite bedrock. The apparent discrepancy shown by the southern Alabama and central North Carolina localities is explained by the presence of limestone erratics and hard-water springs in these areas. At Peebles, Ohio, *P. cordata* grows in a shallow stream directly on dolomitic bedrock. Frequently the roots penetrate the joints of the rock for a distance of 30 cm or more. At Thedford, Ontario, the limestone is within a few

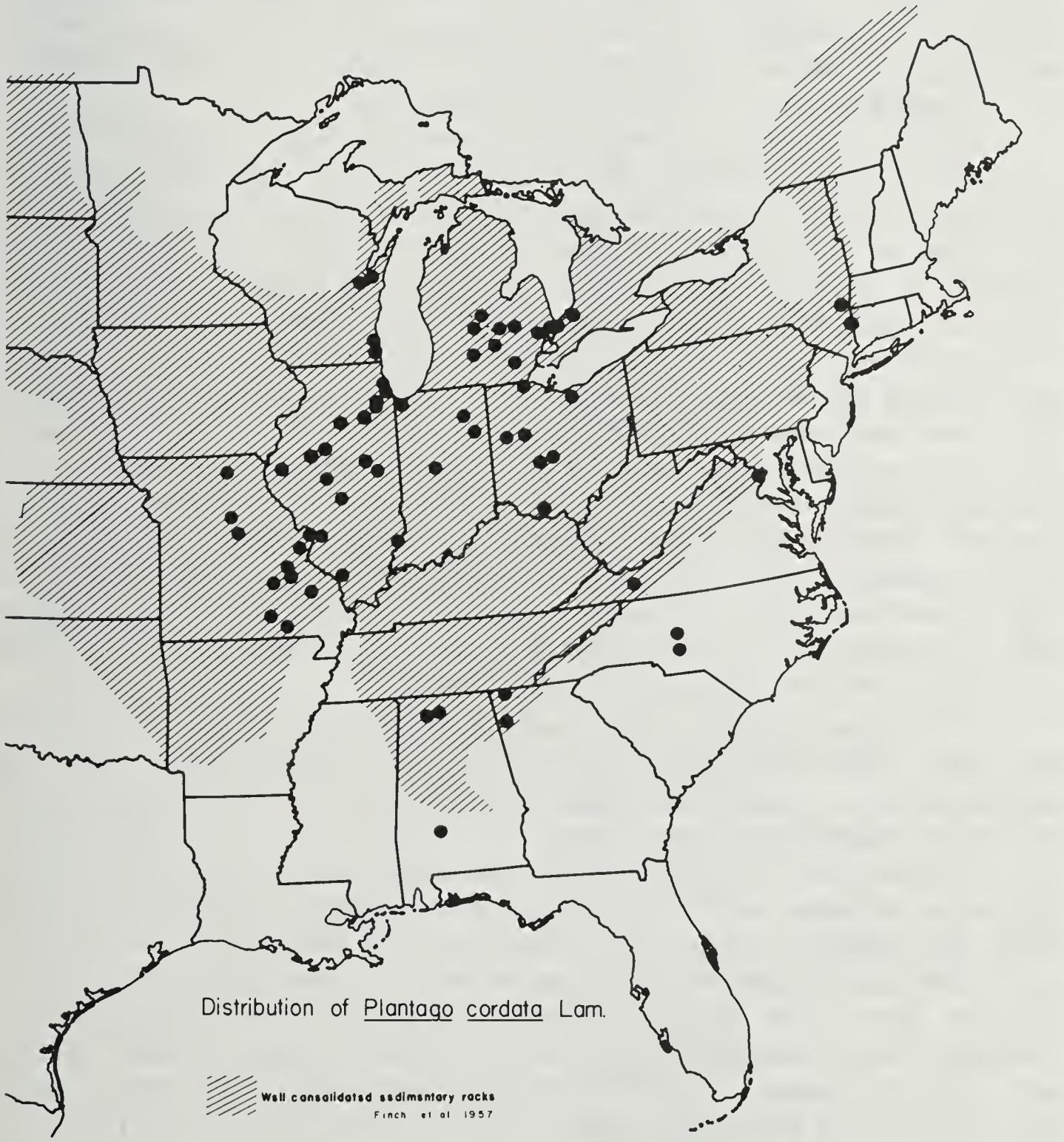

Fig. 12. Distribution of *Plantago cordata.*

feet of the surface although the stream in which the plant is found has a mud bottom. However, the water is highly calcareous as evidenced by marly incrustations remaining around old pools. The bedrock in the immediate vicinity of Lake Murphysboro, Illinois, is a calcareous sandstone. Here *P. cordata* forms small colonies in a shallow pebble-bottomed stream. Although the New Lenox, Illinois, station is located on glacial till, the rocks in the stream bed are mainly calcareous. Many of the old localities which I visited in Michigan, Illinois, Wisconsin, Missouri, and Ohio but where the plantago could no longer be found, were small streams, frequently flowing on limestone bedrock. Although the Stockport Landing, New York, station is within the area supposedly having limestone, the plantagos were growing in thick muddy ooze and non-calcareous alluvial beaches. Bassett (1967) indicates a locality in north-eastern Florida (*S. R. Buckley,* GH) but this is questionable as it is far beyond the more typical limestone areas, the ecology of the area is completely different, and it would be the only station on the Coastal Plain.

Associated species occurring at the various stations are listed in Table II. In general, the physiognomy and composition of the major communities in which the plantago is found are quite diverse. The Thedford, Ontario, population occurs in and along a small, mud-bottommed, slow-moving stream which, as shown by the mud bars and their vegetation and as described by Mr. Bill Henry who guided us to the area, exists as a series of small pools at least part of the year. The stream meanders through a beach-maple woods. The largest tree observed was an *Acer saccharum* with a dbh of approximately 18 inches. The woods and surrounding fields had been grazed and signs of recent use of the stream by cattle were evident. It is possible that this population is, in part, artificially controlled (see below, "Economic Uses"). The population consisted of about 100 individuals spread out along the stream for a distance of approximately 350 m. The largest group—about 40 plants—was the last one seen downstream. (Fig. 13) Dodge, in his flora of the county (1916), implies that the species was at one time, at least, not rare: "Frequent along streams, in pools, ditches, wet places and wooded swamps."

The station at Peebles, Ohio, was visited four times during the course of this study: November, 1965; May, 1966; April, 1967; and June, 1967. The general habitat is a small valley with dolomite walls on both sides and a rapidly flowing stream in the center. Several old stream beds occur scattered in the ravine, showing the old stream course with several switch-backs. The water in the stream is murky with dolomite dust from an adjacent quarry. The area is shady and protected. From the conglomeration of twigs and leaves on many shrubs and trees, it appears that the entire valley is periodically inundated to a depth of several feet. In general, the area is an alluvial plain bordered by a Southern mixed mesophytic forest containing a few trees of *Thuja occidentalis.* Until the summer of 1967, this station was fairly undisturbed; some of the sycamores on the alluvial plain were over four feet dbh. Unfortunately, the valley is now being filled with refuse from the quarrying operations, many trees have been felled, and roads have been built. This situation is most regrettable as the Peebles station supported the largest population of *P. cordata* I

TABLE II. Vascular plants associated with *Plantago cordata.* Listed are those species which occurred within about 10 feet of a plant of *P. cordata.* In some cases, where the topography of the area was very steep, cliff and upland species are included. Although the stations were visted at different times of the year, one can approximate the community composition by the species indicated. The letters following each species give the station(s) where the species was found: I = Lake Murphysboro, Ill.; M = Messenger Woods, New Lenox, Ill.; N = Hudson River, Dutchess Co., New York; O = Plum Run Quarry, Peebles, Ohio; T = Thedford, Ontario. (See text for a general description of each station.)

TREES					
Acer negundo	L				
A. rubrum	L	M			
A. saccharum	L		N	T	
Amelanchier sp.				T	
Carpinus caroliniana				T	
Carya glabra	L				
C. ovata	L				O
Cornus alternifolia			N		O
C. florida	L				
Crataegus spp.	L	M		T	O
Fagus grandifolia				T	
Fraxinus americana	L	M	N		O
Gleditsia triacanthos	L	M			
Liriodendron tulipifera					O
Ostrya virginiana		M	N	T	
Platanus occidentalis	L		N		O
Populus deltoides					O
P. tremuloides			N		
Prunus virginiana				T	
Quercus alba	L	M			
Q. muehlenbergii	L				O
Q. rubra		M			O
Thuja occidentalis					O
Tilia americana		M		T	
Ulmus americana		M	N	T	O
U. rubra		M			
SHRUBS, SUBSHRUBS, & VINES					
Cephalanthus occidentalis				T	
Cornus racemosa		M			
Corylus americana		M			
Euonymus atropupureus	L		N		
E. obovatus			N	T	O
Hamamelis virginiana				T	O
Lindera benzoin	L				O
Parthenocissus quinquefolia				T	
Physocarpus opulifolius			N		O
Rhamnus cathartica		M			
Rhus radicans	L	M	N		O
Ribes cynosbati	L			T	O
Salix interior			N		O
Sambucus canadensis				T	O
Smilax bona-nox	L				
Staphylea trifolia		M			
Viburnum lentago		M		T	
Vitis riparia			N		
Xanthoxylum americanum	L		N		O
HERBS & PTERIDOPHYTES					
Allium sp.	L			T	O
Ambrosia trifida		M			
Anemone quinquefolia				T	
Arisaema atrorubens		M	N	T	O
Asclepias incarnata		M			
Aster novae-angliae		M			
Bidens sp.	L		N		
Boehmeria sp.	L				
Campanula americana		M			
Carex albursina				T	
Carex spp.	L	M	N	T	O
Cicuta sp.		M		T	
Circaea canadensis		M			
Claytonia virginica				T	
Cuscuta sp.				N	
Cyperus sp.				N	
Decodon verticillatus			N		
Desmodium illinoense	L				
Dryopteris marginalis				T	
Equisetum arvense					O
E. hyemale	L		N		
Eupatorium rugosum		M			
E. serotinum	L				
Erythronium americanum				T	
Fragaria virginiana		M		T	
Galium aparine	L	M	N	T	
G. circaezans	L				
Glyceria sp.			N	T	
Geum rivale	L	M		T	
Helianthus sp.	L				
Hepatica acutiloba		M			
Hystrix patula		M			
Impatiens sp.	L	M	N	T	
Iris sp.		M	N		
Lobelia siphilitica	L	M			
Lonicera dioica		M			
Luzula campestris				T	
Lycopus americanus			N		
Lysimachia ciliata				T	
L. nummularia		M		T	
L. quadrifolia			N		
Mertensia virginica					O
Mimulus alatus	L				
Mitella diphylla				T	
Muhlenbergia sobolifera	L				
Nasturtium officinale		M			
Onoclea sensibilis			N	T	
Osmorhiza longistylis		M			
Panax trifolius				T	
Panicum boscii	L				
Pellaea atropurpurea					O
Phaseolus polystachios		M			
Phlox divaricata		M		T	
Phryma leptostachya		M			
Pilea pumila		M			
Plantago lanceolata					O
P. rugelii	L	M	N	T	O
Podophyllum peltatum				T	
Polemonium reptans		M			O
Polygonum sp.			N		
Polymnia uvedalia		M			
Polystichum acrostichoides				T	
Pontederia cordata			N		
Prunella vulgaris	L				
Rumex verticillatus	L				
Sagittaria sp.			N		
Sanicula marilandica		M			
Sanguinaria canadensis		M			
Scirpus atrovirens	L				
Solanum dulcamara			N		O
Sorghastrum nutans			N		
Thalictrum dioicum				T	O
Thaspium barbinode		M			
Typha latifolia			N		
Tiarella cordifolia		M			
Trillium grandiflorum				T	
Uniola latifolia	L				
Verbena hastata		M			
Viola pensylvanica				T	
V. renifolia		M			
V. rostrata				T	
V. sororia	L	M		T	

Fig. 13. *Plantago cordata* in muddy-bottomed stream near Thedford, Ontario. From a color transparency by E. G. Voss, May 6, 1967.

Fig. 14. *Plantago cordata* on gravelly stream bank near Peebles, Ohio, May 8, 1966.

have seen. In May, 1966, I thoroughly explored the area and counted 600 individual mature plants of *P. cordata.* In addition, many seedlings were scattered along the shores of the stream and on the various alluvial bars. (Fig. 14) But here, as at Thedford, the plantago population was not continuous along the stream even though the habitat appeared to extend considerably beyond the area where the last plantago was found. Cedar Creek, above its juncture with Plum Run, did not support any *P. cordata,* although here again the habitat appeared to be the same as that along Plum Run and along Cedar Creek below the juncture of the two streams. The problem of moving upstream is apparent, but why does the population disappear abruptly downstream? This phenomenon I have seen repeatedly but can not explain.

The Hudson River, New York, localities were originally discovered in the early 1800's (Wiegand & Eames, 1926) and have been revisited by several collectors since. I visited these areas in September, 1967. *Plantago cordata* is known from New York only at the Hudson River although there is a report of an old inland locality (Wiegand & Eames, 1926). The New York stations are of particular interest as the plantago grows in slightly brackish water (2-5 ppm, Muenscher, 1937), is subjected to partial inundations by the tide, and grows in open sunlight. The population studied occupies an area of about two acres and consists of several hundred plants. The plantagos occur within three distinct adjacent communities: (1) An association of *Peltandra virginica, Typha latifolia,* and *Decodon verticillatus.* The plantago is common throughout the association but most abundant in the area exposed at low tide. The plants were apparently completely inundated at times as all the leaves and most of the surrounding vegetation were covered with a fine coating of silt. (2) High, open alluvial beach along the river. Here *P. cordata* grows alone or in groups of a few to over 20 individuals. The plants were in full sunlight at 10:00 a.m. The high-beach plantagos are the smallest, although mature, of the combined Hudson River population. (3) A *Salix interior–Acer negundo* swamp. The plantagos in this association are the largest I have observed in either the field or the herbarium. The dense overstory shades the ground-level plants. The resulting shade forms of *P. cordata,* as with most other members of the genus, have unusually wide leaf blades with delicate texture, elongation of the petioles, and a corresponding elongation and narrowing of the spike.

At Lake Murphysboro, Illinois, a man-made lake 47 years old, the plantago occurred as a small population of 30 individuals along a shallow feeder stream for a distance of about 50 m. The woods through which the stream flows is a mixed southern mesophytic association. The dominant trees are *Quercus muhlenbergii, Acer saccharum,* and *Platanus occidentalis. Plantago cordata* grew in the stream and showed no preference for the edges or the middle. The deepest part of the stream was only 10 cm. Three plants of *P. cordata* were also found growing in an unshaded drainage ditch along the road. These are the only plants of *P. cordata* I have seen growing in an obviously disturbed and man-made habitat. No yearling plants were found.

A station near New Lenox, Illinois, was visited in October, 1968. Whether or not this is the same locality that E. J. Hill visited in 1879 is not known

as his data are not specific (In rivulet, New Lenox, Ill. May 17, 1879; *Hill 15.1879*,ILL). If today's station were the same as Hill's locality, this would be the oldest known extant population (see Fig. 15). However, the ecology of the area does not suggest 90 years of undisturbed habitat.

Approximately 250 plants of *P. cordata* grew in the rocky shallows of a small stream for a distance of approximately 550 ft. at the bottom of a ravine. Here, as at the other stations, the habitat appeared to continue both upstream and downstream from the plantago population but the plantago abruptly stopped. Downstream, the creek "went underground" as the streambed became very rocky. The moist streambed was explored for a distance of about one-half mile downstream from where the surface water stopped but no additional plantagos were found. Upstream from the plantago population, the habitat remained similar for a distance of several hundred yards. Beyond that, the canopy was open and the stream passed through an old field.

The dominant trees in the ravine were *Quercus rubra, Ulmus americana, Fraxinus americana,* and *Crataegus* sp. *Impatiens* sp., *Rhus radicans,* and *Polymnia uvedalia* were common in the ravine. The creek itself supported no other vascular plant except *P. cordata.* Several stumps three feet or more in diameter were scattered throughout the area indicating high-cropping in the past.

A comparison of the species associated with *P. cordata* in the five stations studied is given in Table II. The habitat of *P. cordata* is usually a ravine where the immediate vegetation is that of a lowland forest but the nearby surrounding hills support oak-hickory, beech-maple, or mixed mesophytic forests.

As is readily ascertained from the above discussion and Table II, the factors governing the habitat and occurrence of *P. cordata* can not be readily determined from those species and species-associations occurring with it. Therefore, it becomes necessary to look for other sources of data.

Although the absence of an object can not, logically, be shown to prove anything positive, a survey of those habitats known to have once supported *P. cordata* and those habitats which would appear to be able to support it today but do not, can, when compared with extant stations, give some insight in understanding the factors critical to the existence of the species. These data, in conjunction with what historical information one can obtain from the literature, herbarium specimens, and word of mouth, can be correlated into a working hypothesis to explain the ecological behavior and geography of the plant.

REVIEW OF COLLECTING HISTORY AND COLLECTORS

Roland M. Harper (1944) drew an interesting parallel between *P. cordata* and a plant described from Georgia by William Bartram in June, 1773, but whose report was not published until 1943 (F. Harper, ed., 1943; see p. 139). As pointed out by R. M. Harper, the plant mentioned fits the description of *P. cordata* better than any other *Plantago* species. Bartram wrote:

> . . . & in & on the Verge of the Rapid rivulets a great Species of Plantago, in every respect like the common Plantain; except that it is of an incredible magnitude, the leaves with the footstalk commonly 3 feet in length, & in the Broadest part above 12 inches wide, the number of ribs of the leaf being the same with the common Plantain, & run in just the same direction, & by the smell & taist of the Plant seemes to possess the same virtues, but in a greater degree, it grows in the little coves, of the Rivulets & brooks where the eddie water hath collected & raised a Bed of slush or in the middle of the Creeks, where it forms a green Island, about some Rocks or trash.

In interpreting Bartram's description, Harper assumed that it was not *P. cordata* in that (1) the size of the leaf surpassed any specimens known to him; (2) the "ribs" (= veins) were not the same as the common plantago. Here Harper assumes *P. major* but it might just as well have been *P. rugelii* (Tessene, 1968); (3) Harper did not believe that *P. cordata* occurred in Georgia. If Harper had had more specimens available to him, he might have reserved comment on Bartram's description. The size of the leaf, although exceptionally large, is of a magnitude approached by specimens of *P. cordata* growing in very shady areas. (A specimen collected in Illinois in 1961 (*G. N. Jones 32335,* ILL) has a blade 10.2 inches wide.) Georgia in Bartram's time still contained large areas of virgin habitat: One would expect a dense overstory. *Plantago cordata* does occur in Georgia, as has been reviewed recently (Godfrey, 1960). I have no doubt that Bartram's plant was indeed *P. cordata.* From this note and Lamarck's description in 1791, we know that the northern and southern distributional boundaries of *P. cordata* had been established before these and the intervening areas had been markedly influenced by European man.

After these two early descriptions, I have found no record of the plant until 1833 when George Engelmann found it in "Rivers and streams, west of St. Louis" (*Engelmann* April 1933, MO). I. A. Lapham collected it in "Wet places, Columbus O." in April, 1836 (PH). From that time until the 1880's, *P. cordata* was collected sporadically throughout its range. Between 1878 and 1900, many new localities were found (Fig. 15) and most of the specimens extant today date from this period. The reasons for this sudden wealth of collections are probably many and complex and an attempt to explain them would, of necessity, include considerable speculation. *Plantago cordata* may have been collected more frequently before 1880 than the graph indicates; many herbaria of the early botanists have been lost or exist only as remnants. But this is not as important as the paucity of collections since 1900 when more collectors have been in the field than ever before. However, I know of only seven stations for *P. cordata* today. It is a rare plant, but it may always have been rare. It is not necessarily becoming extinct.

During the past three years, I have made numerous trips to many areas and specific localities where *P. cordata* had been collected in the past. Most of the searching was in areas where the plant had been collected since 1920, as these would be the most promising. The seven stations known to be maintaining a population of *P. cordata* (Fig. 15) have been discovered only recently.

Many of the old localities have been obviously destroyed, particularly those near large cities such as Chicago, St. Louis, etc.; but as recently as 1929 *P. cordata* was collected in downtown Milwaukee (stream where North Shore crosses Howell Ave. *Throne* May 12, 1929, UWM). In Table III are listed the old localities which have been searched for and the possible cause for the apparent local extinction of *P. cordata* or failure to find it.

TABLE III. Old localities visited during this study but at which *Plantago cordata* was not found. Most of the localities were suggested by herbarium labels (see appendix for complete citations). The "Present Status" column indicates how each locality differs from what appears to be the natural habitat of *P. cordata* as deduced from extant stations. "Suburbia" covers general destruction of natural habitats in metropolitan areas.

LOCALITY	PRESENT STATUS
MICHIGAN: Brooks and ditches about Alma. Collected 1890-95.	No exact location was given. The general area has been extensively cleared; the remaining woods are widely used as cattle pastures. Streams carry considerable silt from erosion of fields.
MICHIGAN: General vicinity of Michigan State University campus. Collected 1886-95.	The area is now part of the campus of Michigan State University.
MICHIGAN: Vicinity of Port Huron. Collected 1838-1897.	No exact location is given for the Wright or Dodge collections of *P. cordata;* however, the Black River is polluted as is the St. Clair. Many of the small feeder streams in the area look as though they could support *P. cordata* but, to date, it has not been rediscovered.
MICHIGAN: Bank of creek in hardwoods, 5 mi S of Ann Arbor. Collected 1924-25	All streams in the area have been exhaustively scoured but no *P. cordata* has been found. Most of the streams have been rerouted into drainage ditches.
MICHIGAN: West branch of Paint Creek, Ypsilanti township. Collected in 1891.	Farwell returned to his locality in 1928 to look for *P. cordata,* which he did not find. The area, as mentioned by Farwell (1930), has been partly converted into a golf course. Today, the course is overgrown and the area is a gun club. The vegetation along the creek is all second growth. The creek now flows in a drainage ditch for about half its length.
MISSOURI: Vicinity of Allenton: Collected 1879-1923.	The area is now part of suburbia.
MISSOURI: West fork of Fourche a Renault Creek, Washington Co. Collected in 1955.	The creek has been dammed to make a series of ponds upstream. The spring still flows but not profusely enough to fill the creek bed which is now a dry cattle run.
MISSOURI: 3 mi East of Millcreek. Collected in 1965.	This locality was discovered in 1965 but apparently has already been destroyed. The creek is part of a cattle pasture. When visited in October 1968, the upper, less disturbed portions of the creek were dry.

LOCALITY	PRESENT STATUS
NORTH CAROLINA: 5½ mi SE of bridge on N.C. 49 over Yankin River. Collected in 1953.	The locality is now under water as the river has been dammed downstream.
OHIO: Streams west of Toledo. Collected in 1900.	This and several other localities in the vicinity of Toledo are now part of suburbia.
OHIO: End of swamp, E of Indian Lake, Logan Co. Collected in 1928.	The area has been almost completely drained and is now occupied by summer homes. Most of the trees have been removed.
VIRGINIA: Potomac River at Alexandria Light. Collected in 1902.	The area is now an industrial site.
WISCONSIN: Bellevue Creek cascade, Brown Co. Collected 1881-87.	The stream has been rerouted into an irrigation ditch. The cascade is dry.
WISCONSIN: Stream where North Shore crosses Howell Ave., Milwaukee. Collected in 1929.	The stream no longer exists.
WISCONSIN: Woods NE of S 35th Street and Morgan Ave., Milwaukee. Collected in 1938.	The area is now part of suburbia.

The lack of morphological variability in *P. cordata* throughout its range, its early blooming and short-lived seeds, its apparent lack of ecological plasticity, and its resulting rarity, all suggest a highly specialized plant well adapted to a particular biological situation. Controlled experiments in both the greenhouse and in the field have not clearly elucidated the factors controlling the occurrence and maintenance of a population of *P. cordata* under natural conditions, as will be discussed below, have only brought the problem into clearer focus.

Mature plants of *P. cordata* will grow completely submersed for at least four months. They will also survive three months without watering, although under the latter conditions, they will drop their leaves and produce a winter rosette. Six plants survived watering with a 10% NaCl solution for four months after which time they were again given standard treatment. At first the plants showed signs of plasmolysis but after a month and after losing the original leaves, the plants recovered, produced new leaves (with a distinct salty taste reminiscent of *P. maritima*), and appeared quite vigorous. Fifteen adult plants were placed in a sunny, mesic field plot at the University of Michigan Botanical Gardens in the fall. They survived the winter, bloomed and set seed the following spring, survived the summer in a depauperate condition, and have currently produced a winter rosette initiating their second dormant period. The phenological experiments with controlled day-lengths have already

been discussed above.

It is apparent that the adult plants of *P. cordata* can withstand considerable "stress" for at least short periods of time. If there were an ecological catastrophy during a particular growing season, a population would probably survive. However, under none of the experimental conditions did the seeds produce additional plants. The hypothesis is thus supported that the seeds and seedling stages are the critical periods in the life history and biological potential of the species. If the stress conditions lasted over several growing seasons—such as the draining of streams, the opening of the forest canopy, continuous water pollution, damming of streams—the original population would not reproduce and would die either through eventually succumbing to the stress conditions or "old age."

The critical data which are unfortunately lacking at this time concern how *P. cordata* establishes *new* populations across an ecologically disharmonious geographical area. Although Fig. 15 suggests that *P. cordata* is as "abundant" today as in the past, all extant stations are in areas which are relatively undisturbed. There is little reason to believe that these areas have changed much in the last 100-150 years. In light of our present knowledge, Fig. 15

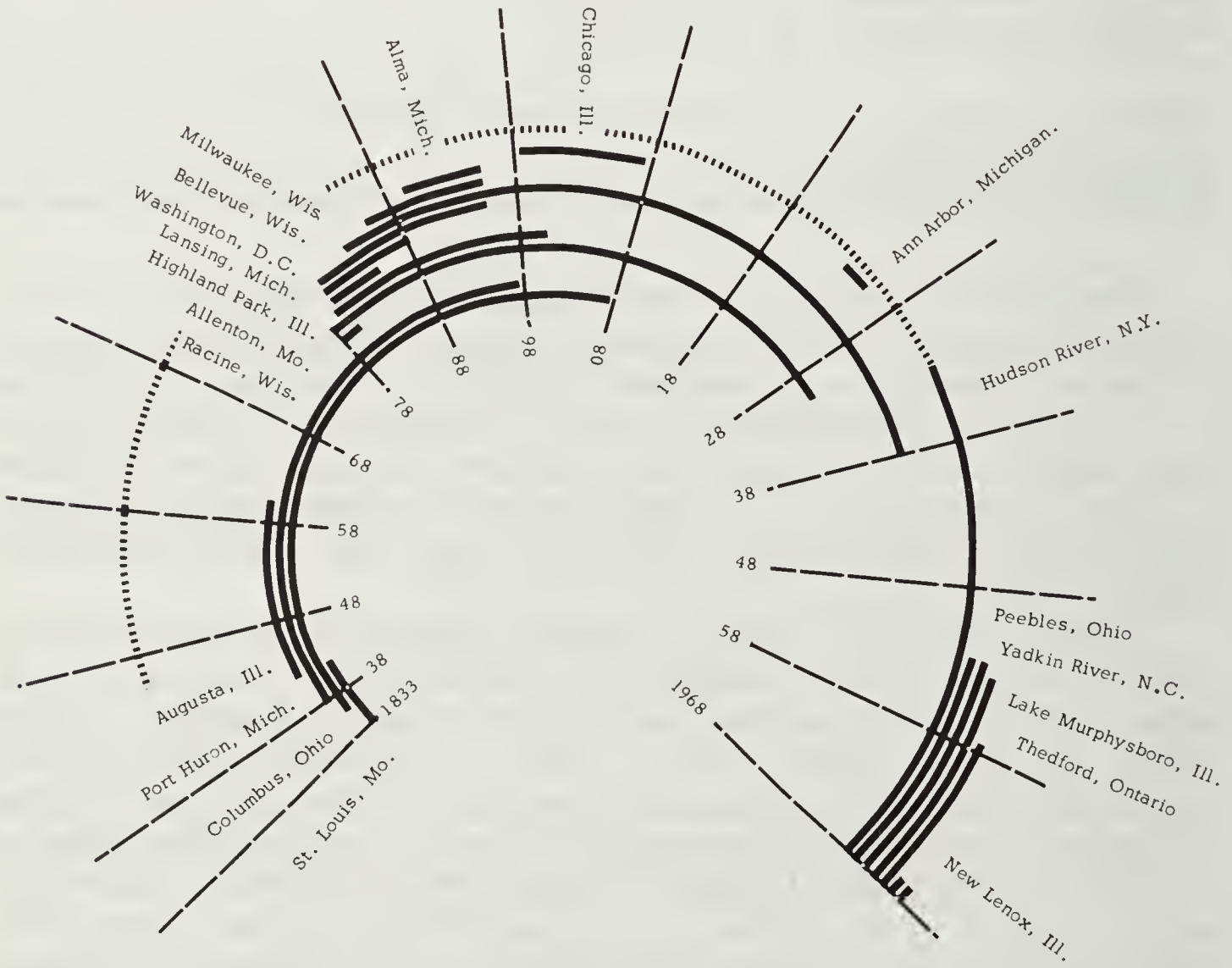

Fig. 15. Longevity of known populations of *Plantago cordata* as indicated by their collecting history. Each arc represents the period of time (if two or more years) during which specimens examined (see Appendix) were collected. (Dotted line for Hudson River represents literature reports which may indicate the same population as more recent [1933-1968] collections.)

could be read as an extinction chart: All presently known stations may have supported populations before European man's disturbance of the area, but gradually other populations have become extinct. As natural areas become fewer and farther between, collectors have to botanize new areas and/or more exhaustively investigate the diminishing older areas. In other case, *P. cordata* has been and surely will be discovered in areas where it had previously not been known. However, this does not mean that the population, *per se,* is new but rather that the population only recently became known to science. Considerable insight on the biology of *P. cordata* could be obtained if the plant suddenly appeared in a well known area which is ecologically suitable for the species but which had not previously supported it. There are many streams in the vicinity of known stations of *P. cordata* where this kind of study could be carried out. Dispersal over larger areas, i.e., ten or more miles, would be interesting to study but extreme discontinuities between potential habitats probably prohibit such dispersal today.

In general, when looking for possible stations of *P. cordata,* one should search for shaded shallow streams with rocky bottoms in calcareous areas where there is little evidence of recent disturbance to the canopy trees. Usually the plantago occurs in streams at the bottom of ravines where little or no alluvial deposition occurs. The plants always occur in the shallowest parts of the stream and usually on gravel bars or rocky areas, but do not occur in areas subject to periodic drought. Many of the streams are subject to high flood levels in the spring as evidenced by the accumulation of debris around trees and in the branches of nearby shrubs.

ETHNOBOTANY AND ECONOMIC USES

The search for *P. cordata* in the Thedford, Ontario, area resulted in a first-hand account of the plant's use as a medicinal herb. Insufficient data on the exact location were given by Gaiser (1966) or on her labels (data supplied by I. J. Bassett) for us to find the plant on our own. Consequently we located Mr. Bill Henry, who is apparently respected among the Potawatomi Indian community of Kettle Point as a "Root-man," i.e. an herbalist. At first, he was unwilling to reveal his locality for the plant, although he immediately recognized *Plantago cordata* from a sketch rapidly made by W. H. Wagner. But after a short discussion which established his fee for services, he led us to the colony and freely described the regular harvest of the plant, of which the roots could be used either fresh or dried.

Among the virtues attributed to *P. cordata,* or "King Root," at this time were healing of burns and relieving of symptoms of sore feet when a tea of its roots is drunk. Mr. Henry's sister, Mrs. Baxter Shawkence, said it would "Heal you when you hurt." Bill Henry mentioned that sometimes *P. cordata* is mixed with other herbs in a tea. He frequently mentioned that it was good for "50 diseases" but this may well have been an exaggeration. The plantago was supposed to be particularly good as a physic. If it worked "too well," Henry said

he had another plant that would "shut you off." He also mentioned that *P. cordata* "could kill you." We were told that King Root was also "good for claps" but were not given any details. On the way back to our car, he said "I think it can cure stomach cancer." I asked "You mean it helps a belly-ache?" He said "Yes."

Psyllium seed or *Plantago* seeds have long been used in many cultures as a cathartic, and the leaves have been applied to wounds to promote healing (Shyreu, 1935). H. H. Smith (1933) in discussing the use of *Plantago major* [*Plantago rugelii?*] among the forest Potawatomi, refers to a slippery fluid obtained by boiling the root. This was then used to lubricate the throat when one was choking or coughing. I attempted to make such a "tea" out of the roots of *P. major* and *P. rugelii* but did not obtain a "slippery fluid." However, when *P. cordata* roots are treated similarly, a slimy gruel is readily obtained. "King Root" may therefore have been used in this preparation rather than *P. major* or *P. rugelii,* a theory supported by the anatomical evidence of abundant starch in the roots of *P. cordata* and little or no starch in the other species. Smith continues discussing the Indian uses of plantain, listing the use of a heated leaf to bind on swellings and inflammations, of fresh leaves to dress wounds and heal sores, and of a tea made from the plant for its supposed alterative, diuretic, antiseptic, and antisyphilitic properties.

Material of *P. cordata* was given to Dr. Ara Paul, Department of Pharmacognosy, University of Michigan, for analysis. His screening resulted in discovery of no particular medicinal properties of the plant, save its well-known cathartic one.

Regardless of the after-effects, *P. cordata* can apparently be eaten as food. Steyermark (1963) in his discussion of the species states that the "young fleshy leaves and tender petioles may be cooked as a vegetable, and of all the native plantains is the most tender."

Plantago cordata is a showy plant, as pointed out by Steyermark (1963) and has been cultivated in gardens since the time of Lamarck. Even today, it occasionally appears in commercial plant catalogues specializing in aquatic plants.

As a rare and fascinating species, hopefully, *P. cordata's* last domain will not be that from which it was, perhaps ominously, originally named—a garden.

APPENDIX: SPECIMENS EXAMINED

CANADA. ONTARIO: Near Conrad River, *Booth,* May 17, 1863 (US); Near Amherstburg, *Macoun,* June 10, 1882 (US); Lambton Co., 1½ mi N Thedford, *Tessene, Hines, Voss, & Wagner 1941,* May 6, 1967 (MICH); Local in small stream and on muddy bank where slightly marly, low deciduous woods (of Harvey Lockney) W of Hgy. 82, ca. 2 mi. NW Thedford. Roots medicinal, fide Bill Henry, part-Indian herbalist of Kettle Point, *Voss 12424,* May 6, 1967 (MICH). *UNITED STATES.* ALABAMA: Colbert Co., Shallow rocky bed of Fox-trap Creek, *Harper 3892,* July 25, 1942 (MO, US); Wet rocky bank of Ligon's Creek about 2 mi W of Lusliville [Littleville?], *Harper 3933,* April 20, 1943 (MO, US); Wilcox Co., *Buckley,* April 18, '10 (NY). DISTRICT OF COLUMBIA: Vicinity of Washington, *Ward,* May 2, 1881 (NY); *Ward,* May 18, 1884 (MSC). GEORGIA: Catoosa Co., Shallow soil in Cedar Barrens 1.9 mi E, 18 mi N Fort Oglethorpe, *Duncan*

& McDowell 12236, 31 March 1951 (MO); Frog Co., Banks of Hordey Creek near Rome, *Chapman 4366* (MO, US). ILLINOIS: Champaign Co., In running water, Urbana, *Mamis 17606,* May 6, 1882 (ILL); Christian Co., Taylorville, *Andrews,* 5-27. 99 (ILL); Cook Co., Chicago, *Boerde,* May 22, 1886 (ISC, US); Glencoe, in sandy mud in small creek at base of ravine, *Gates 1692.1,* June 22, 1907 (ILL, US); Johnson, May 8, 1889 (MICH); In water, ravines at Winnetka, *Moffatt,* May 10/91 (ILL, MINN, NY); Rivulet, Avondale, *Moffatt 2495,* May 14, '94 (WIS); N of Chicago, *Moffatt,* June 10/94 (ILL); Ravines, Glencoe, *Pepoon 10187,* June 9, 1898 (WIS); North Evanston, *Price,* 1893 (US); Edge of streams, Evanston, *Shipman,* 1897 (MICH, PH); Englewood, *Williamson,* Aug. 1893 (PH). Grundy Co., Morris, *Slossow* (PH). Hancock Co., Augusta, *Mead,* May, 1842 (NY); *Mead 6681,* May, 1860 (MO). Lake Co., Rivulets in ravine, Highland Park, *Hill 16.1880,* May 22, 1880 (ILL); *Umbach,* June 9, 1900 (MINN, PH, WIS). Jackson Co., Stream of NE end of Lake Murphysboro, *Tessene 2066,* Oct. 13, 1967 (MICH). LaSalle Co., In water at bottom of canyon, Matthiessen State Park, near Oglesby, *G. Jones 32335,* June 30, 1961 (ILL). Marshall Co., Along streams, *Heading,* May, 1879 (ILL). Menard Co., Revulets [sic], Athens, *Hall 31313,* April, 1863 (ILL). Peoria Co., Peoria, *Brendel,* May 22, 1859 (ILL); In brooks, Canton, Pekin, abundant, *Buckley* (NY). Piatt Co., Creeks, Mansville [Mansfield?], *Johnson,* May 14, 1900 (US). St. Clair Co., Mascoutah, *Welsch,* 1862-1871 (ILL). Wabash Co., Chiefly about Mt. Carmel, *Schneck* (ILL). Will Co., In rivulet, New Lenox, *Hill 15.1879,* May 17, 1879 (ILL). INDIANA: Boone Co., Lebanon, *Cunky,* May, 1861 (PH). Porter Co., Swampy ground by streams, Wheeler, *Hill 56.1884,* July 4, 1889 (ILL). Wells Co., Rock Creek, *Deam,* 5-27-1900 (MINN). Whitley Co., Boggy stream on Gradless farm about 7 mi E of Columbia City, *Friesner 20424,* 6-13-1946 (MICH, MO, NY). MICHIGAN: Eaton Co., Bellevue, *Mr. [D. A.] Shoop* [ca. 1868] (MICH). Genesee Co., Flint, *Clark* (MO, NY, OS, PH, US). Gratiot Co., Brooks and ditches in mud, vicinity of Alma, *Davis,* June 10, 1890 (MSC); *Davis,* May 22, 1893 (US); *Davis,* May 26/93 (MINN); *Davis,* May 29/95 (ILL, MICH, WIS). Ingham Co., Lansing, [Cooley coll.] 5/5/87 (MSC); Dr. Beal's woods, Agricultural College, *Skeels,* June 6, 1894 (MSC); Lansing, Michigan Agricultural College, [Collector unknown], May 22, 1886 (MSC). Ionia Co., Wet ground, Hubbardston, *Wheeler* (MICH, MINN); Macomb Co., Vicinity of Washington, *Cooley,* 1843 (MSC). St. Clair Co., Port Huron, *Dodge 423* (MO); *Dodge 6193* (MINN, WIS); along shaded streams plentiful, *Dodge,* 5-22-92 (MICH); *Dodge,* May 9, 1897 (ILL); along streams in woods, occasional, often water, *Dodge,* May 31, 1897 (MICH, MSC); *Wright,* June 2, 1838 (MICH). Shiawassee Co., Owosso, in slow streams, *Hicks,* May 18, 1889 (BLH, MICH). Washtenaw Co., Along bank of creek in hardwoods at "Hickory Flats" 5 mi S of Ann Arbor, *Erlanson 29,* May 15, 1924 (MICH); Ditch in low, rich woods 5 mi S of Ann Arbor, *Ehlers,* May 16, 1924 (MICH); *Ehlers 3154* (MICH); *Ehlers 3156* (MICH, WIS); [Hammond woods near Ypsilanti. Frequent. fide Farwell's field catalog], *Farwell 1087,* 5-28-91 (BLH). MISSOURI: Adair Co., Moist woods, bank along stream and in water of stream in ravine, Tributary of Chariton River between Kirksville and Moroings, *Steyermark 18857,* May 4, 1935 (US). Atchison Co., Near Fairfasse [Fairfax?], *Eggert,* 20 May, 1887 (MO). Boone Co., Webster, *Eggert,* 24 May, 1887 (ISU, MO). Dent Co., Growing in a creek, Miss Shoop's farm, near Sligo, *Lodewyks 284,* May 12, 1935 (MINN, MO); Margin of stream bed in gravel where seepage accumulates along north prong of Mehang River T34N, R4W, sec 11, *Steyermark 12517,* Aug. 4, 1936 (MO). Carter Co., *Mann 2064,* 5-1-1891 (MO). Howard Co., Along Creek around rocky exposures, rich woods, slopes and ravine along Maniteau Creek from Blue Bluff south and SW T51N, R14W, sec 10, 4 mi NE of Bunke Hill, 8 mi NE of Burton, *Steyermark 74265* (MO). Jefferson Co., In shallow running water or rocky stream bed near mouth of Buffdale Hollow, SW of Selma, *Steyermark 8048,* April 15, 1934 (MO). Montgomery Co., In creeks, Montgomery, *Engelmann,* April, 1863 (MO). Ripley Co., At base of limestone bluff along spring branch of prong of south fork of Buffalo Creek, T34N, R1E, sec 35, 5 mi E of Bradley, *Steyermark 11792,* July 14, 1936 (MO). St. Louis Co., St. Louis, *Buckley* (ISU, MO); Wet places, *Eggert,* 27 April, 1887 (ILL, MO, NY, US); In streams and . . . [sic!] etc. west of St. Louis, *Engelmann,* April, 1833 (MO); *Engelmann,* April, 1842 (PH, US, WIS); In small rivulets, *Geyer,* April, 1842 (PH, MO); On bed of small

stream, Flat Rock, Allen [ton?], *Greenman 4214,* April 15, (NY); Flat Rock, *Hurshel 5378,* April 15, 1923 (US); Allenton, *Kellogg,* June 18, 1886 (MO); *Kellogg 15302,* May 20, 1930 (MO); *Letterman,* Dec. 23, 1879 (OS); *Letterman,* Mar., 1880 (NY); *Letterman,* April 10, 1888 (ILL); *Letterman,* 1890 (MO, NY, US); *Letterman,* July 1, 1894 (MO, PH); Eaux Contantes, St. Louis, *Riehl,* April 1838 (NY); Sandy beds of streams, Kirksville, *Sheldon,* 5/31/'83 (OS). Shannon Co., Monteer, Common in streams, *Bush 373,* May 24, 1900 (NY, US). Washington Co., Sugar Camp Hollow (tributary to Indian Creek) T39N, R1W, sec 24, 5½ mi (by air) E of Anthonies Mill, moist limestone rocks along creek, *Steyermark 77806,* Sept. 27, 1954 (ILL); Common in spring branch and slough at base of limestone bluffs along west fork of Fourche à Renault Creek, T37N, R1E, sec 27, 1 mi S of Shirley, *Steyermark 78632,* June 13, 1955 (ILL). NEW YORK: Columbia Co., N side of Chekomeko Creek, "Ralph Jenson Kill," Livingston tnsp., *Hines 6825* (MICH); Along creek at RR bridge, Stockport Landing, *Tessene, S.J. Smith, et al. 2065* (MICH). Dutchess Co., Gravelly shores of the Stony Creek S of the Madaline Bridge, at Ward Manor, *Elwert,* May 14, 1933 (NY); In brackish water on the gravelly shores of Crueger's Island in the Hudson, between the stations of Barytown and Tivoli, *Elwert,* June 8, 1933 (NY); Rocky banks of Imbrocht Bay, *Muenscher & Curtis 5810,* Sept. 3, 1936 (WIS); South Bay, *Muenscher & Curtis 5811,* Aug. 31, 1936 (PH). Green Co., Tidal marshes of Hudson River, Green Point 4 mi S of Catskill, *House 25135,* Sept. 2, '37 (NY). NORTH CAROLINA: Stanley Co., 5½ mi SE of bridge on N.C. 49 over Yadkin River, *Radford 7071,* June 4, 1953 (ILL). OHIO: Adams Co., Stream at Beaver Pond, *Bartley & Pontius 958,* May 27, 1945 (NY, US); Local in bottom of Plum Run Creek, by Plum Run Quarry, off rt. 31, ca. 2.6 mi E of Peebles, water and soil very limey, Meigs twp., *Stuckey 2880,* 29 May 1966 (OS); *Tessene, W. H. Wagner, et al. 1881,* Nov. 13, 1965 (MICH); *Tessene & Stuckey 1918,* May 29, 1966 (MICH); Common in a small but fast-flowing stream through juniper savana, N of Plum Run quarry, with Floyd Bartley, *Voss 1531,* April 9, 1953 (MICH). Auglaize Co., St. Marys, *Wetzstein,* 22 April, 1897 (OS). Erie Co., *Moseley,* May 19, 1895 (BGSU). Champaign Co., From watery pools on Mad River, Urbana, *Samples,* May 26th 1838 (MICH). Franklin Co., "Sellsville," Columbus, *Craig 6975,* June 1889 (OS); Columbus, *Kellerman,* 1 June 1895 (OS); *Lapham,* April, 1836 (PH); *Lloyd,* April 1891 (ISU, NY); *Osborn,* July '97 (OS); *Selby,* April 25, 1891 (OS); *Tyler,* October 2, 1907 (OS); *Werner,* May, 1891 (OS); Georgesville, *Werner,* 24 Sept. 1892 (OS); Worthington, [Collector unknown], June (ISC). Logan Co., End of swamp east of Indian Lake, Richland tnsp., *Hine,* 16 May, 1928 (OS). Lorain Co., Very wet woods, infrequent, Oberlin, *Cowles,* May 21, 1892 (OS); *Dick,* 12 May, 1894 (OS); *Dick,* 4-29-95 (MINN); *Ricksecher,* May 12, 1894 (NY, US); shallow stream, South woods, *Strong,* May 21, 1892 (MICH). Lucas Co., Stream 3 miles W of Toledo on Dorr St., *Burglehaus,* 6 May, 1900 (OS). Madison Co., London, *Sharp,* 1900 (OS). VIRGINIA: Smyth Co., Vicinity of Marion, Alt. 2100 ft. Ravine of the Holston, *N. & E. Britton & Vail,* June 8, 1892 (NY); On bar extending into Potomac River at Alexandria Light, Chesapeake Bay rgion, *Shull 217,* Aug. 13, 1902 (MO, NY). WISCONSIN: Brown Co., Bellevue Creek Cascade, *Schuette,* May, 1887 (NY); Ledge near Bellevue Creek, *Schuette,* May 15, 1881 (MINN). Kenosha Co., Somers, *Wadmond,* June 3, 1899 (MINN, WIS). Milwaukee Co., Creek S.W. of Layton Park, Milwaukee, *Finger,* June 17,-01 (MIL); Root River, Milwaukee, just north of Racine Co., line, Elm woods, growing in water (flood pools), *Fuller 4524,* May 12, 1932 (MIL); Oak Creek, *Goessl,* Sept. 21, 1935 (WIS); Milwaukee, *Hassee 13557* (MIL); *House,* May '84 (PH); *Lapham* (NY, WIS); In stream, woods NE of S 35th and Morgan Ave., *Shinners,* May 11, 1938 (UWM); New Coeln, Along ditch in woods, *H. Smith,* May 24, 1921 (MIL); Slow moving stream where North Shore crosses Howell Ave., *Throne,* May 12, 1929 (UWM); Schwiechert's Woods, Wauwautosa, *Wheeler 7596,* June 24-26, 1887 (MIL). Racine Co., Racine, *Davis,* June 28, 1897 (WIS); *Davis,* May 21, 1880 (WIS); Root River, "near Milwaukee Co. line–LMS," *Oppel U-15,* Aug. 1935 (WIS). Outagami Co., *Kellerman,* June 1879 (US).

ACKNOWLEDGMENTS

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A NEW LOCATION FOR *PORELLA PINNATA* IN LOWER MICHIGAN[1]

John S. Russell
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On August 11, 1965, during a search for aquatic flowering plants, a large liverwort subsequently identified as *Porella pinnata* L. was collected (*Russell,* UMBS, MICH) near the mouth of Mud Creek at the west side of Black Lake in Cheboygan County. Specimens (Fig. 1) were found in large, luxuriant, olive-green or blackish clumps on tree roots submerged by as much as two feet of murky water. Visual evaluation of the habit of the plant was not possible owing to the darkness of the water, although it appeared to occur

[1]Contribution from the University of Michigan Biological Station.

in proximity to, and often mixed with, *Riccia fluitans* L. Fragments of *Porella* were seen floating near the surface of the water, and depauperate clumps were observed on tree roots above the surface. The creek is cold, slow-moving, and probably slightly alkaline. The site was visited two days later and additional material collected by Miller and Crum (1966).

Fig. 1 (left). *Porella pinnata,* about natural size, from Mud Creek near Black Lake.

Fig. 2 (below). A portion of the same collection, enlarged about 8 times.

The only previous authenticated collections of *Porella pinnata* from Michigan are those made by Nichols (1935, 1938) in Marquette County in the Upper Peninsula and Gilbert (1958) in Iosco County in the Lower Peninsula. The present find confirms the reported occurence of this species in the University of Michigan Biological Station region (Gilbert, 1958). Both of Nichols' specimens were found attached to submerged rocks, while Gilbert listed "submerged rocks and other materials" as the substrate. An investigation of data accompanying specimens from North America in the University of Michigan Herbarium confirms the fact that in northerly locations *Porella pinnata* is almost always found submerged, while on more southerly sites it frequently thrives on moist soil, and sometimes in rich woods. Schuster (1953) noted that in the South it occurs on cypress knees, on the bark of beeches, or as a xerophyte on rocks far from any source of constant water. He suggested the existence of a diverse series of genotypes to account for this apparent broad range of ecological tolerance, to which Conard has also recently called attention (1968).

Because of its preference for submerged substrates in the northerly reaches of its range, *Porella pinnata* may be more common in this area than heretofore suspected. A more thorough knowledge of the ecology of its preferred habitat may indicate that this liverwort is not rare, but merely local in occurrence and difficult to find. Plants of this species are characterized by leaves scarcely touching, narrow non-decurrent underleaves, and similarly tongue-shaped underlobes (Fig. 2).

According to distribution records given by Frye and Clark (1946), *Porella pinnata* L. is widespread in the South and East. I have examined specimens from Vt., Mass., R.I., N.J., Pa., Va., W.Va., N.C., S.C., Ga., Fla., Tenn., La., Tex., Mo., Ark., Ind., Ill., Ohio, Mich., Ont., N.S.

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Editorial Notes

We hope to see all members and friends of the Michigan Botanical Club at the annual Spring Campout, to be held this year in the Manistee National Forest, near Irons, in Lake County, Michigan. Full information will be sent to all members in advance.

With some pride, we observe that, entirely by coincidence, *all* of the excellent articles in this issue are by graduate students at Michigan universities.

The January number (Vol. 8, No. 1) was mailed January 3, 1969.

Errata

In addition to a few more obvious transpositions of letters or other spelling alterations, the following may be noted:

Vol. 7, No. 3, p. 141, line 3 from bottom: for "4183" read 4138
p. 188, line 8 from bottom: for "44:" read 45:
Vol. 8, No. 1, p. 39, line 19: for "east" read ease

Publications of Interest

(Continued from p. 66)

PAPERS ON PLANT SYSTEMATICS. Selected by Robert Ornduff. Little, Brown & Co., Boston, 1967. 429 pp. $6.00. This is an anthology of 14 biosystematics papers selected from the massive literature of experimental taxonomy. Included are papers published in 14 different journals, mostly in America and mostly in the last 20 years. In his preface to the ecology section, Ornduff notes that the role of ecological studies in plant systematics is not as influential as it should be. Systematists are largely ignoring potentially profitable and simpler techniques of ecology while using the more complex techniques of numerical and chemical taxonomy. Overall, the book is an excellent introduction to the literature of biosystematics. The papers illustrate the major areas of morphological, cytological, biochemical, and ecological approaches to solving systematic problems.

—E. L. McWilliams

WEEDS OF THE WORLD. By Lawrence J. King. Interscience Publ., New York, 1966. 525 pp. $18.00. Although there are numerous books available on the subject of weeds, this one is unique both in its scope and in its strong emphasis on the biology of weeds. Taxonomic identification of weeds is not considered. The topics covered include origins of weeds, ecological classification of weeds, parasitic weeds, germination, establishment, growth, dispersal, and evolution of weeds. There is an entire chapter on weed sociology with a bibliography of over 175 references. The extensive bibliographies at the end of each chapter are among the most useful aspects of the text. The book is well illustrated with photographs and diagrams. The last section deals with weed control, both chemical and non-chemical, with some consideration to the impact of herbicides on our ecosystem. This volume will be useful to a variety of biologists, especially students of weed biology, as well as agriculturists.

—E. L. McWilliams

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(On the cover: Spring is coming!
April photo of Hepatica americana *taken near*
Midland, Michigan, by Harold F. Tweedie.)

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THE

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THE MICHIGAN BOTANIST—Published by the Michigan Botanical Club four times per year: January, March, May, and October. Second-class postage paid at Ann Arbor, Michigan.

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Articles and notes dealing with any phase of botany relating to the Upper Great Lakes Region may be sent to the editor in chief. The attention of authors preparing manuscripts is called to "Information for Authors" (Vol. 6, p. 202; reprints available from the editor).

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THE INTRODUCTION AND SPREAD OF *LYCOPUS ASPER* (WESTERN WATER HOREHOUND) IN THE WESTERN LAKE ERIE AND LAKE ST. CLAIR REGION[1]

Ronald L. Stuckey
College of Biological Sciences,
The Ohio State University, Columbus

In many studies of eastern North American plants distinctions are usually made between those species which are native (or indigenous) and those which are introduced (or non-indigenous). This distinction is often clear and seems to present few problems. The basic idea is that those species which were here originally (i.e., before the coming of European man) are native, and those species that have appeared since the arrival of European man and that are known to be indigenous to another continent have been introduced, have spread, and in many cases have become established as part of the flora. Little evidence is ever presented that a native species may be expanding its range, and that in reality it, too, is a newcomer or non-indigenous member of a particular floristic region. These non-indigenous members may be considered truly part of the original flora until their proper status is determined.

Because habitats and the environment of the continent are continually changing, often as the result of man's activities, changes in the distribution of certain species of the native flora are to be expected. It is imperative that those studying plants understand the changing flora in order to evaluate man's impact on the environment. The distributions of individual species give clues to these changes, which can be recognized only after a comparison is made of information from past literature and herbarium specimen records with modern surveys of plants in the field. This paper brings together data from these sources as evidence to show that *Lycopus asper* Greene (western water horehound), a species indigenous to western North America, is non-indigenous to the shore flora of the western Lake Erie and Lake St. Clair region.

Western water horehound (fig. 1), a member of the mint family (Labiatae), is a short, 4-8-dm-tall plant with sessile, toothed, oblong-lanceolate, spreading to ascending leaves. The white-petaled flowers are somewhat inconspicuous in the axils of leaves, where later in the year four nutlets appear. Vegetative reproduction is by short, thick stolons and runners, which form long, thick tubers at their tips. Because of the absence of showy parts, the plants blend together with other members of the community, and therefore individuals of *L. asper* may go unnoticed in the field.

Henderson (1962), in his taxonomic revision of the genus *Lycopus,* maps the known occurrence of *L. asper* for North America. The species is distributed throughout western United States and southern Canada and from his map appears to be more commonly found in western Minnesota, western

[1]Contribution from the Botany Program (Paper No. 756), the Herbarium, and The Franz Theodore Stone Laboratory.

Fig. 1. *Lycopus asper* Greene (western water horehound) among cat-tails in wet sand at the east end of Erie Road along the shore of Lake Erie, Monroe County, Michigan. Photographed 14 September 1968 by William H. Anderson.

Iowa, Nebraska, South Dakota, and North Dakota. Henderson points out that a gap exists in its distribution in eastern Iowa and Minnesota, and throughout most of Wisconsin. Across northern Illinois and about Lake Michigan, Lake Huron, and western Lake Erie the species occurs at several stations. Henderson suggests that this distribution pattern could indicate either an accidental introduction and establishment eastward or a lack of collecting in the intervening area, or both. He concludes, however, that this distribution perhaps reflects the actual occurrence of this species rather than omissions in collecting. Fernald (1950) points out that *L. asper* is occasionally adventive along railways eastward in its range. Gleason (1952) notes that it is rare and probably adventive east to southwestern Ontario. In Illinois, where it is known from Bureau, Whiteside, Cook, Henry, and Lake counties, *L. asper* is treated as a native species by

Dobbs (1946), Jones et al. (1951), Jones and Fuller (1955), and Jones (1963). Deam (1940) excludes western water horehound from Indiana because an earlier report was based on a misidentified specimen. The species was found in 1946 in Lake County, Indiana, along a weedy shore of Wolf Lake opposite the city park at Whiting (*Friesner 21121,* MICH, US). Henderson (1962), who also observed *L. asper* at the same lake shore, reports that this is the only known Indiana locality. Koeppen (1958) reports *L. asper* as occasionally adventive in Wisconsin along railroad tracks and Lake Michigan harbors in Sheboygan, Waukesha, and Milwaukee counties. Because Waterman (1960) does not indicate that *L. asper* is non-indigenous in Michigan, her treatment implies that the species is native where it occurs in the counties of Berrien, Cheboygan, Mason, Monroe, St. Clair, and Wayne, all of which border the Great Lakes and connecting waters. Waterman (personal communication) has informed the author that she did not consider or attempt to evaluate the status of *L. asper* in the Michigan flora at the time of her study. Voss (1957) says that Michigan is apparently the eastern limit of its native range, but believes western water horehound is not indigenous to Cheboygan county. In papers concerned with introduced plants, Montgomery (1957) and Rousseau (1968) do not mention *L. asper* for Ontario and Quebec, respectively. Isolated localities for western water horehound are known in Ontario at Hamilton, Wentworth County (*Caesar,* 8 Aug 1957, HAM; *Tamsalu* 7 Aug 1957 and 22 Jul 1958, HAM), at Keene, Peterborough County (*Campbell,* Aug 1922, DAO), at Rideau River near White's Bridge, Carleton County (*Minshall 3895,* 16 Aug 1947; *Dore & Erskine 14086,* 13 Sep 1952; *Dore 18507,* 4 Sep 1960; *Dore, Koyama, Gillett 20007,* 22 Jul 1962, all DAO); in Quebec at Saint Nicholas (*Marie-Victorin & Rolland-Germain 56805,* 24 Aug 1942, photo DAO) and Pointe Mesakonan (*Dutilly & Lepage 36732,* 16 Aug 1958, photo DAO); and in Bergen Swamp, Genesee County, New York, where Zenkert (1934) reports it as very rare, based on House's collection of 1916. Muenscher (1946) does not mention the species from Bergen Swamp. From the above information it appears that in the Great Lakes region *L. asper* is widely scattered and its status is somewhat confused. Careful examination of the available evidence presented below leads me to conclude that *L. asper* is non-indigenous at least to the region about the western end of Lake Erie and Lake St. Clair.

Because of a long history of floristic study, the western Lake Erie-Lake St. Clair region is particularly well suited to the study of the changing aquatic and shore flora. Two of the earliest and very detailed aquatic plant surveys for the United States were conducted on portions of these two lakes (Pieters, 1894, 1901). Through the years various investigators have reported on the flora of the surrounding region as well as on these lakes. Newberry (1860), Beardslee (1878), Kellerman and Werner ("1893" [1894]), Kellerman (1899), Schaffner (1914, 1932), and Weishaupt (1960, 1968) do not list *L. asper* for Ohio. For Michigan the species is not mentioned by Wheeler and Smith (1881) or by Beal and Wheeler (1892), but Beal (1905) included it under the name *Lycopus lucidus* Turcz., now known to have been misapplied to American plants. Macoun (1883) did not list it for southwestern Ontario.

Several studies on the aquatic and shore plants of more limited portions of the western Lake Erie-Lake St. Clair region provide documentation for the presence or absence of *L. asper* and the approximate time when western water horehound appeared. The species is not reported for Lake St. Clair by Pieters (1894), for Detroit (Farwell, 1902), for parts of the Detroit River (Foerste, 1882; Campbell, 1886), for the Canadian shore of western Lake Erie (Burgess, 1888-9; Dodge, 1914; Montgomery, 1957), or for the Ohio portions of western Lake Erie (Claassen, 1892; Moseley, 1899; Pieters, 1901; Burr, 1901; Schaffner, 1902; Kellerman, 1904; Kellerman and Jennings, 1904; Fullmer, 1916; Core, 1948, 1949; Pinkava, 1963; Wood, 1966; Albright, 1966; Lowden, in press). Specimens of *L. asper* have not been found, under any name, among the collections of most of these botanists.

Dodge (1900) is the earliest known writer to mention *L. asper* in the western Lake Erie-Lake St. Clair region, as well as for the entire state of Michigan. Using the name *L. lucidus,* he reported it as "plentiful about the elevators in the city of Port Huron. Only locality noticed. An immigrant from the west." Dodge's specimens at MICH were obtained in 1892 and 1896. Dodge (1910) did not mention western water horehound in a preliminary report on the flora of Lambton County, Ontario, but he later (1916) wrote that the plants were "well established around grain elevators and along railways" in Lambton County. The species was not known farther south until Farwell (1918) reported it from the banks of the Detroit River at Wyandotte, based on a specimen collected 20 August 1916. Billington obtained a specimen from Grosse Isle along the Detroit River on 4 September of the same year. The earliest specimen known for the shore of western Lake Erie dates from August 1920 and was collected by Moseley at Toledo Beach in Monroe County. Based on field work in 1949, McDonald (1951) recorded the species as rare on the beach at Pointe Mouillée Marsh.

L. asper was not known in the Lake St. Clair vicinity until 1920 and 1924 when the plants were found on Squirrel Island in the St. Clair River (*Farwell 5680½*) and Walpole Island (*Farwell 7085*), respectively. The species was again found on Walpole Island in 1944 (*Groh 2271*). In 1948 plants were obtained from near waste ground on the bank of the Sydenham River at Wallaceburg (*Bassett & Mulligan 772*) and from sandy soil near the Thames River Light House (*Soper & Dale 4077*). Although not specifically studying the shore plants of Harsens Island, Hayes (1964) did report some of the species of wet habitats, such as *Juncus balticus, J. torreyi, Lycopus americanus, Lythrum alatum, Potentilla anserina,* and *Verbena hastata,* but he did not mention *Lycopus asper.* Gaiser and Moore (1966) list *L. asper* for Walpole Island only. Western water horehound's present distribution in the Lake St. Clair region bears investigation.

In the Ohio portion of western Lake Erie, the flora of the islands and nearby mainland has been extensively studied by professionals, amateurs, and students, many of whom are or were associated with the botany program at The Franz Theodore Stone Laboratory. However, *L. asper* was not known as part of the flora until a plant was obtained from Honey Point on North Bass

Island by Doris Albright in 1965 (not reported by Albright, 1966) and from the shallow water over dolomite rock on the south shore of East Point on South Bass Island by me in 1967 (Stuckey, 1968a). In August 1968, I observed four plants on the sandy beach of Lake Erie at Lakeview Park in Port Clinton. Western water horehound may have first appeared at this site in 1968 because palnts were not found there when I extensively surveyed the Park's shore in 1967. In 1968 the plants were in places where fresh sand, washed by the waves earlier in the season, came into contact with the stable sand of the beach. In September 1968, I saw numerous plants in wet beach sand at the east end of Erie Road and at Sterling State Park along the western shore of Lake Erie in Monroe County, Michigan. It appears that western water horehound is spreading throughout western Lake Erie, particularly at sites where there is some beach sand, such as at Honey Point, Lakeview Park, Erie Road, and Sterling State Park. I have searched especially for this species in beach sand blown in among cat-tails along the lake shore at Magee Marsh (Crane Creek State Park) in the southeastern corner of Lucas County. Other sites in western Lake Erie where sand is common and where I have conducted extensive field work and found no *L. asper* are Middle and East Harbor (East Harbor State Park), Sand Point Marsh at the southeastern corner of the Marblehead Peninsula, the north shore of Kelleys Island at the State Park, and along the beach and about the ponds at the north and south points of Pelee Island. Based on its apparent present colonization behavior, *L. asper* would be expected to invade these sandy beach sites earlier than other less favorable habitats such as those along the rocky and rubble shores.

How the plants have spread in western Lake Erie is an interesting question about which we have little information. The location of plants along the relatively fresh sand at Lakeview Park suggests that the seeds were washed ashore and then germinated. Ridley (1930, p. 222) points out that *Lycopus europaeus* (a species of similar habitats and seed morphology) is specially adpated for dispersal in rivers. Its seeds apparently remain viable after floating from 12 to 15 months. Because *L. asper* is a rather inconspicuous member of the flora at locations where plants have been found, it is doubtful that man has deliberately been responsible for its dispersal in our region.

The apparent distributional history of *L. asper* is remarkably similar to that of *Butomus umbellatus* (flowering-rush) (Stuckey, 1968b). Both species appear to have moved into western Lake Erie from along the Detroit River. Knowledge of the distributional history of flowering-rush in our area is certainly more complete than it is for *L. asper,* because the former is a much more conspicuous plant. Its showy pink flowers on tall stalks are easily seen by both professional and amateur botanists throughout the entire summer and fall. *B. umbellatus* is also more likely to have been moved around, planted, and cultivated by man for its showy flowers and possible food source for wildlife, than is the western water horehound.

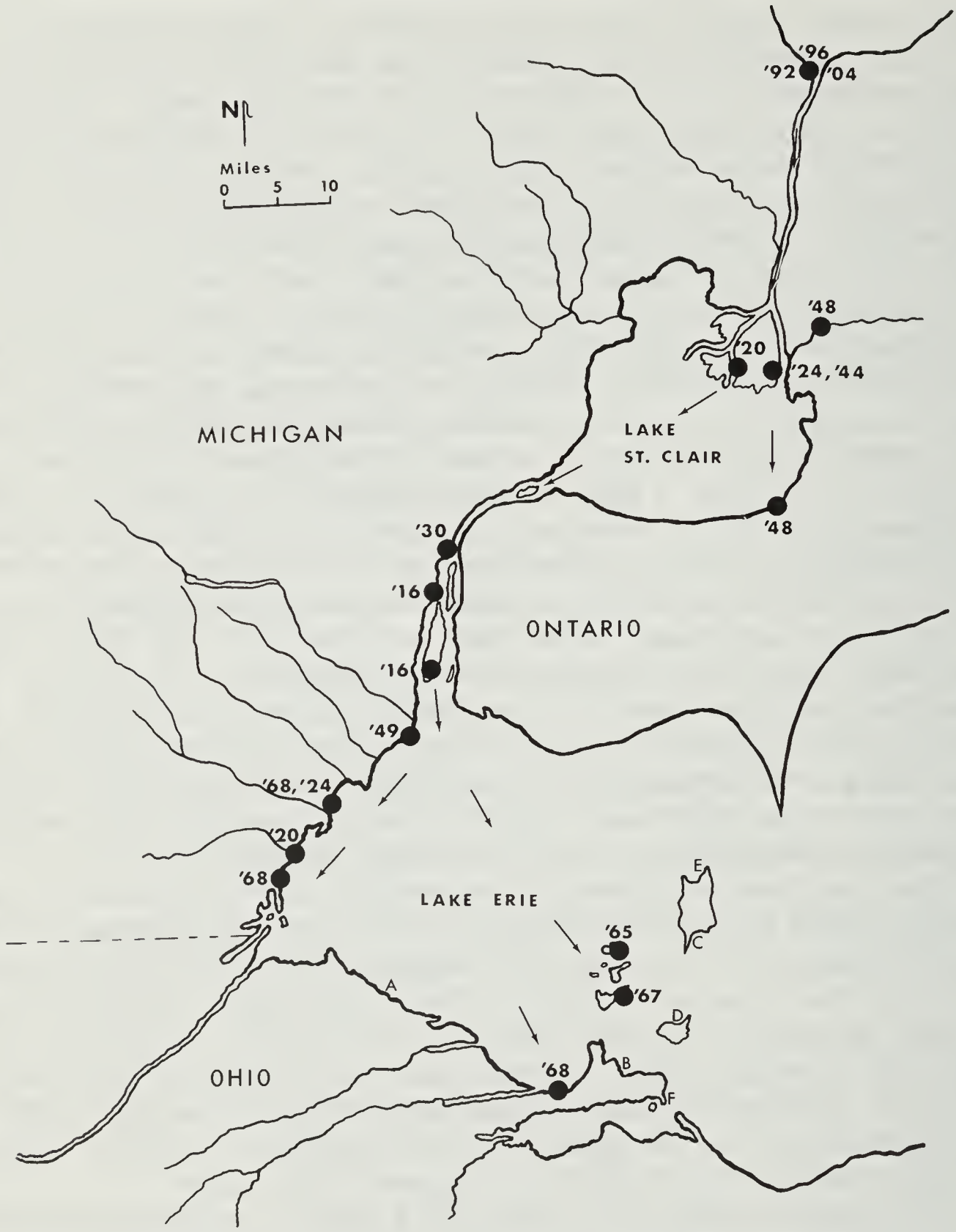

Fig. 2. Known distribution of *Lycopus asper* Greene in the western end of Lake Erie and Lake St. Clair region based on herbarium specimens cited in this paper. The date(s) indicate the known collection(s) from each locality represented by a dot. The arrows indicate the probable pathway by which the species has migrated. This pathway follows the general flow of water through the St. Clair River, Lake St. Clair, the Detroit River, and southeastward through the western end of Lake Erie. Letters along the south shore and islands of Lake Erie represent locations of sandy beaches where I have searched unsuccessfully for *L. asper.*

A: Crane Creek State Park
B: East Harbor State Park
C: Fox's Pond and Fishing Point, Pelee Island
D: Kelleys Island State Park
E: North Lagoon and Lighthouse Point, Pelee Island
F: Sand Point Marsh

SUMMARY AND CONCLUSIONS

A review of literature and herbarium records, together with field studies, has made it possible to work out the probable distributional history of *Lycopus asper,* a species native to western North America, in the region about the western end of Lake Erie and Lake St. Clair. In recent literature it has been treated in our region as an indigenous species, perhaps because it occurs in naturally disturbed habitats, such as wet, shifting beach sands. The conclusion that *L. asper* has been introduced and then spread in our region is based on

1. The assumption that field studies in this region have adequately sampled the flora over the past 80 years.
2. Absence of the species from most of the early floristic literature of Michigan, Ohio, and southwestern Ontario, as well as from studies on small areas within this region. Even though any one individual studying and reporting on the flora of a given area might have overlooked *L. asper,* the fact that a large number of early investigators of this region did not find and report it is indicative that the species must have been absent or very local.
3. The earliest known records of Dodge (1900, 1916), who reported that the species was a western immigrant found about grain elevators and along railways in Port Huron and the surrounding area. Dodge knew the flora well in the field and his specimens are labeled with data similar to his published reports.
4. The subsequent dates and locations of plant collections following Dodge, which reveal the approximate time and the probable pathway that *L. asper* has used in spreading southward through the St. Clair River, Lake St. Clair, the Detroit River, and western Lake Erie (fig. 2). Its direction of spread in western Lake Erie is consistent with the prevailing direction of surface water flow (see map, Federal Water Pollution Control Administration, 1968, fig. 25). The conclusion that *L. asper* has had this distributional history further assumes that separate introductions did not occur, as suggested by the absence of the species from Ohio floristic literature concerning western Lake Erie until 1968.

SPECIMENS EXAMINED FROM THE WESTERN LAKE ERIE–LAKE ST. CLAIR REGION

MICHIGAN: MONROE CO.: Monroe Piers, 27 May 1924, *Farwell 7074* (MICH); barrier beach, Pointe Mouillée State Game Area, 10 Aug 1949, *McDonald 5386* (MICH); Toledo Beach, 6 Aug 1920, *Moseley s.n.* (BGSU); locally common in wet sand along edge of cat-tail marsh along shore of Lake Erie at the e end of Erie Road, n edge of Sec. 14, Erie Twp., ca. 3 mi e of the town of Erie, 14 Sep 1968, *Stuckey 7757* (OS, PH); occasional in wet sand on beach along shore of Lake Erie, s w corner of Sec. 35, Frenchtown Twp., n edge of Sterling Monroe State Park, e edge of the city of Monroe, 14 Sep 1968, *Stuckey 7761* (OS); frequent in low hollow back of sandy shore of Lake Erie, n edge Sec. 14, Erie Tp., ca. 3 mi e of Erie, 14 Sep 1968, *Voss 12843* (MICH, MSC). ST. CLAIR CO.: Plentiful, about grain elevator, city of Port Huron, 25 Aug 1892, *Dodge s.n.* (MICH); plentiful, near grain elevator, city of Port Huron, 20 Aug 1896, *Dodge s.n.* (MICH); frequent along railroads and grain elevators, near Port Huron, *Dodge s.n.,* 5 Aug 1904 (US). WAYNE CO.: Low, damp ground, Grosse Isle, 4 Sep 1916, *Billington s.n.* (MICH); Wyandotte, 20 Aug 1916, *Farwell 4384* (MICH); River Rouge, 9 Sep 1930, *Farwell 8767* (MICH).

OHIO: OTTAWA CO.: Honey Point, North Bass Island, *Albright 105* (OS); local (three plants). in shallow water along dolomite shore, s e side of East Point, South Bass Island, ca. ¼ mi s of Buckeye Island, 11 Aug 1967, *Stuckey 4950* (MICH, OS); portion from one of four plants seen on wet sandy beach, NE ¼ Sec. 5, T6N, R17E, Portage Twp., Lakeview Park, e edge of Port Clinton, 19 Aug 1968, *Stuckey 7450* (CAN, DAO, MICH, OS, PH).

ONTARIO: ESSEX CO.: Sandy soil dredged from drain 0.5 mi s of Thames River Light House, Tilbury Twp., 26 Jul 1948, *Soper & Dale 4077* (DAO, US). LAMBTON

CO.: Near waste ground, bank of Sydenham River, Wallaceburg, 24 Jul 1948, *Bassett & Mulligan 772* (DAO); Squirrel Island, 16 Sep 1920, *Farwell 5680½* (MICH); Walpole Island, 3 Sep 1924, *Farwell 7085* (MICH); Walpole Island, 25 Jul 1944, *Groh 2271* (DAO).

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I have examined all specimens cited immediately above. All specimens cited elsewhere in the text have been seen except those from the Royal Botanical Gardens Herbarium (HAM), Hamilton, Ontario, for which the data were supplied by Dr. James S. Pringle. Sincere appreciation is given to the curators of the various herbaria. Specimens or records of specimens have been seen from the following herbaria: BGSU, CAN, DAO, HAM, MICH, MO, NY, OS, PH, TRT, US.

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MOSSES FROM SOUTHERN MICHIGAN: NEW DISTRIBUTIONAL RECORDS[1]

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During the summer of 1967, a course in Bryology was offered by the W. K. Kellogg Biological Station of Michigan State University. As a result of field studies connected with this course and our own independent studies, two species new to the state, *Schwetschkeopsis denticulata* and *Sematophyllum carolinianum*, and 246 new county records were established that were not listed in Darlington's recent *Mosses of Michigan* (1964). These new distributional records are cited in the following list. Voucher specimens are deposited in the herbaria of the W. K. Kellogg Biological Station and/or Southwest

[1]Contribution No. 165 from the W. K. Kellogg Biological Station of Michigan State University.

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Missouri State College. Duplicate collections of the Sphagnaceae and new state records have also been deposited in the Herbarium of the University of Michigan. Numbers in parentheses are the collection numbers of the senior author unless otherwise indicated. Details of the localities cited in this list are as follows:

Barry County:

Glass Creek. Hardwood forest near junction to tributary of Glass Creek and Pine Lake Road. NE ¼ sect. 7, T. 2 N., R. 9 W.

Otis Lake. East edge of Otis Lake. NE ¼ sect. 31, T. 3N, R. 9 W.

Sager Road. Hardwood forest near junction of Sager and Shaw Roads. NE ¼ sect. 1, T. 2 N, R. 10 W.

Purdy Lake. Bog and adjacent hardwood forest. NW ¼ sect. 36, T. 1 N, R. 9 W.

Lawrence Lake. Alkaline Bog. Sect. 27, T. 1 N, R. 9 W.

Hardwood Swamp. East of Hwy. 37, ca. 4 mi. south of Dowling, SE ¼ sect. 16, T. 1 N, R. 8 W.

Berrien County:

Berrien Springs. Steep slopes along small spring-fed gullies. Ca. 1.5 miles NE of Berrien Springs. Sect. 8, T. 6 S., R. 17 W.

Warren Woods. Warren Woods State Park. Sect. 27, T. 7 S., R. 20 W.

Eaton County:

Grand Ledge. Wooded slopes and sandstone bluffs. Fitzgerald Park. SW ¼ sect. 2, T. 4 N, R. 4 W.

Ingham County:

Wooded Deciduous Swamp. Sect. 33, T. 2 N., R. 1 E.

Sanford Woodlot. Michigan State University. East Lansing.

Kalamazoo County:

Kellogg Biological Station. Sect. 6, T. 1 S., R. 9 W.

Kellogg Bird Sanctuary. Sect. 8, T. 1 S., R. 9 W.

Kellogg Forest. Spruce forest and hardwood-pine forest. Sect. 22, T. 1 S., R. 9 W.

Larix Bog. Ca. 2 miles south of Portage. Sect. 28, T. 3 S., R. 11 W.

Larix-hardwood Bog. Near Gull Lake. Sect. 20, T. 1 S., R. 9 W.

Mason County:

Hardwood Swamp. Ca. 3 miles north of Ludington. Sect. 33, T. 19 N., R. 18 W.

Ludington State Park. Beech forest and hardwood swampy areas. Sect. 17, T. 19 N., R. 18 W.

Sand Dunes. Ca. 3 miles north of Ludington. Sect. 33, T. 19 N., R. 18 W.

Shiawassee County:

Rose Lake Wildlife Research Station. Flood plain forest. Sect. 28, T. 5 N., R. 1 E.

SPHAGNACEAE

Sphagnum capillaceum (Weiss) Schrank var. *tenellum* (Schimp.) Andr. Barry Co.: Purdy Lake (22226). Kalamazoo Co.: Larix Bog (21942, 22072, 22075, det. by H. Crum). Mason Co.: Ludington State Park (22011, 22038).

Sphagnum cuspidatum Ehrh. ex Hoffm. Kalamazoo Co.: Larix Bog (21946, det. by H. Crum).

Sphagnum fimbriatum Wils. ex Hook. f. Barry Co.: Otis Lake (22101, det. by H. Crum).

Sphagnum girgensohnii Russ. Kalamazoo Co.: Hardwood-Larix Bog (22085).

Sphagnum papillosum Lindb. Barry Co.: Purdy Lake (22224). Kalamazoo Co.: Larix Bog (21943).

Sphagnum squarrosum Sw. ex Crome. Mason Co.: Hardwood Swamp (22068, det. by H. Crum).

Sphagnum subsecundum Nees ex Sturm. Mason Co.: Hardwood Swamp (22050).

TETRAPHIDACEAE

Tetraphis pellucida Hedw. On humus and logs. Barry Co.: Hardwood Swamp (22242). Mason Co.: Ludington State Park (22004). Shiawassee Co.: Rose Lake (Halbert 1234).

FISSIDENTACEAE

Fissidens adianthoides Hedw. On humus and decaying logs. Barry Co.: Lawrence Lake (22215). Mason Co.: Ludington State Park (21989).

Fissidens bryoides Hedw. On soil. Kalamazoo Co.: Kellogg Forest (21898).

Fissidens cristatus Hedw. ex Mitt. On humus and decaying logs. Barry Co.: Glass Creek (22127). Mason Co.: Hardwood Swamp (22067).

Fissidens osmundioides Hedw. On log. Mason Co.: Hardwood Swamp (22046).

Fissidens taxifolius Hedw. On soil. Barrien Co.: Berrien Springs (22305). Eaton Co.: Grand Ledge (22390).

DITRICHACEAE

Ceratodon purpureus (Hedw.) Brid. On sandy soil and bases of trees. Barry Co.: Sager Road (22096). Kalamazoo Co.: Kellogg Biological Station (22188). Mason Co.: Sand Dunes (22042).

Ditrichum pallidum (Hedw.) Hampe. On soil and bases of trees. Barry Co.: Glass Creek (22131). Kalamazoo Co.: Kellogg Bird Sanctuary (21953).

DICRANACEAE

Dicranella heteromalla (Hedw.) Schimp. On soil. Barry Co.: Purdy Lake (22236). Shiawassee Co.: Rose Lake (Halbert 784).

Dicranum bonjeanii De Not. ex Lisa. On humus. Mason Co.: Ludington State Park (22022).

Dicranum flagellare Hedw. On humus and decaying wood. Berrien Co.: Berrien Springs (22300). Mason Co.: Ludington State Park (21991).

Dicranum fulvum Hook. On vertical sandstone. Eaton Co.: Grand Ledge (22379).

Dicranum montanum Hedw. On humus and tree bases. Barry Co.: Glass Creek (22155). Berrien Co.: Warren Woods State Park (22263). Mason Co.: Ludington State Park (21992).

Dicranum polysetum Sw. On humus. Mason Co.: Ludington State Park (22027), Hardwood Swamp (22055).

Dicranum scoparium Hedw. On humus and soil. Barry Co.: Otis Lake (22100), Glass Creek (22150). Berrien Co.: Berrien Springs (22303). Kalamazoo Co.: Kellogg Forest (21913). Mason Co.: Ludington State Park (22009). Shiawassee Co.: Rose Lake (Halbert 795).

Dicranum viride (Sull. & Lesq. ex Sull.) Lindb. On tree trunks. Barry Co.: Glass Creek (22156). Berrien Co.: Warren Woods State Park (22271).

LEUCOBRYACEAE

Leucobryum glaucum (Hedw.) Ångstr. ex Fr. On soil, humus, and decaying logs. Barry Co.: Purdy Lake (22227). Berrien Co.: Berrien Springs (22321). Kalamazoo Co.: Hardwood-Larix Bog (22079). Mason Co.: Ludington State Park (21990).

POTTIACEAE

Barbula unguiculata Hedw. On soil. Berrien Co.: Berrien Springs (22298). Kalamazoo Co.: Kellogg Biological Station (22333).

Desmatodon obtusifolius (Schwaegr.) Schimp. On stone wall. Kalamazoo Co.: Kellogg Biological Station (22194).

Gymnostomum recurvirostrum Hedw. On creek bank. Berrien Co.: Berrien Springs (Halbert 628).

Phascum cuspidatum Hedw. var. *americanum* Ren. & Card. ex Card. & Thér. On old field soil. Kalamazoo Co.: Kellogg Biological Station (Halbert 1-13).

Tortula mucronifolia Schwaegr. On stone wall. Kalamazoo Co.: Kellogg Biological Station (22221).

Weissia controversa Hedw. On soil. Barry Co.: Glass Creek (22153). Kalamazoo Co.: Kellogg Biological Station (Halbert 1-13).

GRIMMIACEAE

Grimmia apocarpa Hedw. var. *alpicola* (Hedw.) Hartm. On stone walls. Eaton Co.: Grand Ledge (22380). Kalamazoo Co.: Kellogg Biological Station (22193).

FUNARIACEAE

Funaria hygrometrica Hedw. On soil. Berrien Co.: Berrien Springs (22297). Mason Co.: Sand Dunes (22044).

Physcomitrium pyriforme (Hedw.) De Not. On old field. Kalamazoo Co.: Kellogg Biological Station (Halbert 1-26).

BRYACEAE

Bryum angustirete Kindb. ex Mac. On sandstone ledges. Eaton Co.: Grand Ledge (22350, 22362).

Bryum argenteum Hedw. On soil. Berrien Co.: Berrien Springs (22316). Kalamazoo Co.: Kellogg Biological Station (Halbert 8). Mason Co.: Sand Dunes (22043).

Bryum caespiticium Hedw. On rotting stumps. Shiawassee Co.: Rose Lake (Halbert 94).

Bryum capillare Hedw. On tree bases. Barry Co.: Otis Lake (22103). Mason Co.: Ludington State Park (22035).

Bryum pseudotriquetrum (Hedw.) Gaertn., Meyer, & Scherb. On logs. Barry Co.: Lawrence Lake (22220). Berrien Co.: Berrien Springs (22302). Kalamazoo Co.: Kellogg Biological Station (Halbert 415). Mason Co.: Hardwood Swamp (22062).

Leptobryum pyriforme (Hedw.) Wils. On vertical sandstone. Eaton Co.: Grand Ledge (22361).

Pohlia nutans (Hedw.) Lindb. On soil. Berrien Co.: Berrien Springs (22326). Kalamazoo Co.: Kellogg Forest (Halbert 194). Mason Co.: Ludington State Park (22013). Shiawassee Co.: Rose Lake (Halbert 629).

Rhodobryum roseum (Hedw.) Limpr. On soil banks. Berrien Co.: Berrien Springs (22295).

MNIACEAE

Mnium affine Funck. On soil. Barry Co.: Glass Creek (22120, 22124). Berrien Co.: Berrien Springs (Halbert 594). Kalamazoo Co.: Kellogg Forest (21888). Eaton Co.: Grand Ledge (22389). Mason Co.: Hardwood Swamp (22061).

Mnium cuspidatum Hedw. On soil and decaying logs. Barry Co.: Glass Creek (22139). Berrien Co.: Warren Woods (22265). Kalamazoo Co.: Kellogg Bird Sanctuary (21958). Shiawassee Co.: Rose Lake (Halbert 1233).

Mnium marginatum (With.) Brid. ex P. Beauv. On soil and sandstone. Barry Co.: Glass Creek (22162, 22174). Eaton Co.: Grand Ledge (22377).

Mnium medium B. S. G. On soil. Berrien Co.: Berrien Springs (22328).

Mnium punctatum Hedw. On humus and logs. Berrien Co.: Warren Woods (22288). Eaton Co.: Grand Ledge (22392). Mason Co.: Ludington State Park (22019).

Mnium punctatum var. *elatum* Schimp. Base of shrub. Mason Co.: Hardwood Swamp (22057).

Mnium stellare Hedw. On humus and decaying logs. Barry Co.: Glass Creek (22154). Berrien Co.: Berrien Springs (22309, 22319).

AULACOMNIACEAE

Aulacomnium androgynum (Hedw.) Schwaegr. On humus. Mason Co.: Ludington State Park (22017).

Aulacomnium heterostichum (Hedw.) B. S. G. On soil. Barry Co.: Glass Creek (22134). Berrien Co.: Berrien Springs (22304). Kalamazoo Co.: Kellogg Forest (21911).

Aulacomnium palustre (Hedw.) Schwaegr. On humus and decaying wood. Barry Co.: Otis Lake (Halbert 1228). Berrien Co.: Berrien Springs (22320). Kalamazoo Co.: Larix Bog (22069). Mason Co.: Ludington State Park (22023). Shiawassee Co.: Rose Lake (Halbert 781).

BARTRAMIACEAE

Bartramia pomiformis Hedw. On soil. Barry Co.: Glass Creek (22136). Berrien Co.: Berrien Springs (22332).

Philonotis fontana (Hedw.) Brid. var. *caespitosa* (Jur.) Dix. On log. Barry Co.: Lawrence Lake (22213, duplicate det. by H. Crum).

TIMMIACEAE

Timmia megapolitana Hedw. On soil. Barry Co.: Glass Creek (22169).

ORTHOTRICHACEAE

Orthotrichum ohioense Sull. & Lesq. ex Aust. On hardwood trees. Barry Co.: Glass Creek (22165).

Orthotrichum pumilum Sw. On hardwood tree. Ingham Co.: Sanford Woodlot (Halbert 8a).

CLIMACIACEAE

Climacium americanum Brid. On soil, edge of creek. Berrien Co.: Berrien Springs (22312). Shiawassee Co.: Rose Lake (Halbert 1230).

Climacium dendroides (Hedw.) Web. & Mohr. On log. Mason Co.: Hardwood Swamp (22052).

THELIACEAE

Myurella sibirica (C. Müll.) Reim. On vertical, shaded sandstone. Eaton Co.: Grand Ledge (22373).

Thelia asprella Sull. Base of oak. Barry Co.: Otis Lake (S. N. Stephenson, Aug. 1967).

FABRONIACEAE

Schwetschkeopsis denticulata (Sull.) Broth. On base of maple. Berrien Co.: Warren Woods (22276).

LESKEACEAE

Leskea gracilescens Hedw. On tree trunks and logs. Ingham Co.: Sanford Woodlot (Halbert 20). Kalamazoo Co.: Kellogg Forest (21932).

Leskea obscura Hedw. On base of tree. Berrien Co.: Warren Woods (22286).

Lindbergia brachyptera (Mitt.) Kindb. On tree trunk. Ingham Co. Sanford Woodlot (Halbert 8a).

THUIDIACEAE

Anomodon attenuatus (Hedw.) Hüb. On soil, humus, rocks, and tree bases. Barry Co.: Otis Lake (22110). Berrien Co.: Warren Woods (22270). Eaton Co. Grand Ledge (22352). Ingham Co.: Sanford Woodlot (Halbert 13). Kalamazoo Co.: Hardwood-Larix Box (22082). Mason Co.: Hardwood Swamp (22047).

Anomodon rostratus (Hedw.) Schimp. On humus. Barry Co.: Glass Creek (22140). Shiawassee Co.: Rose Lake (Halbert 789).

Haplocladium microphyllum (Hedw.) Broth. On log. Berrien Co.: Warren Woods (22264).

Thuidium delicatulum (Hedw.) B. S. G. On soil, humus, and decaying logs. Barry Co.: Hardwood Swamp (22248). Berrien Co.: Warren Woods (22268). Kalamazoo Co.: Kellogg Forest (21900). Mason Co.: Ludington State Park (22016). Shiawassee Co.: Rose Lake (Halbert 1235).

Thuidium minutulum (Hedw.) B. S. G. On decaying log. Shiawassee Co.: Rose Lake (Halbert 79).

AMBLYSTEGIACEAE

Amblystegium compactum (C. Müll.) Aust. On sandstone. Eaton Co.: Grand Ledge (22354).

Amblystegium juratzkanum Schimp. On logs. Barry Co.: Glass Creek (22138). Mason Co.: Ludington State Park (22031).

Amblystegium serpens (Hedw.) B. S. G. On rocks and trees, Barry Co.: Purdy Lake (22232). Berrien Co.: Berrien Springs (22324). Ingham Co.: Sanford Woodlot (Halbert 7). Kalamazoo Co.: Kellogg Biological Station (22189).

Amblystegium varium (Hedw.) Lindb. On tree bases and logs. Berrien Co.: Berrien Springs (22290). Mason Co.: Hardwood Swamp (22065). Shiawassee Co.: Rose Lake (Halbert 51).

Calliergon cordifolium (Hedw.) Lindb. On log. Mason Co.: Hardwood Swamp (22066).

Calliergonella cuspidata (Hedw.) Loeske. On humus and logs in wet places. Barry Co.: Lawrence Lake (22218). Mason Co.: Hardwood Swamp (22054).

Calliergonella schreberi (Brid.) Grout. On soil and humus. Kalamazoo Co.: Larix Bog (22071).

Campylium chrysophyllum (Brid.) J. Lange. On soil. Kalamazoo Co.: Kellogg Biological Station (22199).

Campylium hispidulum (Brid.) Mitt. On soil and decaying wood. Barry Co.: Glass Creek (22122, 22151). Berrien Co.: Berrien Springs (22317).

Campulium stellatum (B. S. G.) C. Jens. On moist soil. Barry Co.: Lawrence Lake (22214).

Cratoneuron filicinum (Hedw.) Spruce. On humus and soil in wet places. Barry Co.: Glass Creek (22163). Berrien Co.: Berrien Springs (22310). Kalamazoo Co.: Kellogg Biological Station (22191).

Drepanocladus aduncus (Hedw.) Warnst. var. *polycarpus* (Bland. ex Voit) Roth. f. *gracilescens* (B. S. G.) Moenk. On wet humus. Barry Co.: Glass Creek (22160, dup. examined by H. Crum).

Drepanocladus uncinatus (Hedw.) Warnst. On wet soil. Kalamazoo Co.: Kellogg Forest (21896, dup. det. by H. Crum).

Hygroamblystegium fluviatile (Hedw.) Loeske. On sandstone in creek. Eaton Co.: Grand Ledge (22383).

Hygroamblystegium tenax (Hedw.) Jenn. On logs in wet places. Barry Co.: Glass Creek (22173). Berrien Co.: Warren Woods (22266). Kalamazoo Co.: Kellogg Biological Station (22196).

Leptodictyum kochii (B. S. G.) Warnst. On log. Barry Co.: Sager Road (22098).

Leptodictyum riparium (Hedw.) Warnst. On humus, wood, and rocks in wet places. Barry Co.: Glass Creek (22142). Berrien Co.: Berrien Springs (22331).

Leptodictyum trichopodium (Schultz) Warnst. On humus. Barry Co.: Lawrence Lake (22217). Kalamazoo Co.: Kellogg Biological Station (Halbert 416).

BRACHYTHECIACEAE

Brachythecium acuminatum (Hedw.) Rau & Herv. Base of tree. Berrien Co.: Warren Woods (22284, examined by H. Robinson).

Brachythecium campestre (Hedw.) B. S. G. On soil. Kalamazoo Co.: Kellogg Forest (21903, examined by H. Robinson).

Brachythecium oxycladon (Brid.) Jaeg. & Sauerb. On soil and sandstone. Berrien Co.: Berrien Springs (22318, dup. examined by H. Crum). Eaton Co.: Grand Ledge (22351). Kalamazoo Co.: Kellogg Biological Station (22195, examined by H. Robinson).

Brachythecium plumosum (Hedw.) B. S. G. On soil. Kalamazoo Co.: Kellogg Forest (21901, examined by H. Robinson).

Brachythecium rivulare (Hedw.) B. S. G. Soil and humus in wet places. Barry Co.: Glass Creek (22118, examined by H. Robinson). Berrien Co.: Berrien Springs (22311, examined by H. Robinson). Kalamazoo Co.: Kellogg Forest (21894, examined by H. Robinson). Shiawassee Co.: Rose Lake (Halbert 777).

Brachythecium rutabulum (Hedw.) B. S. G. On soil and decaying logs. Berrien Co.: Warren Woods (22293, examined by H. Robinson). Kalamazoo Co.: Kellogg Forest (21935, examined by H. Robinson).

Brachythecium salebrosum (Web. and Mohr) B. S. G. On soil and logs. Barry Co.: Glass Creek (22147, examined by H. Robinson). Shiawassee Co.: Rose Lake (Halbert 1229).

Brachythecium velutinum (Hedw.) B. S. G. On soil. Barry Co.: Otis Lake (22106, det. by H. Robinson). Kalamazoo Co.: Kellogg Forest (21914, examined by H. Robinson).

Bryhnia graminicolor (Brid.) Grout. On soil. Barry Co.: Glass Creek (22175).

Bryhnia novae-angliae (Sull. & Lesq. ex Sull.) Grout. On soil. Mason Co.: Ludington State Park (22001).

Eurhynchium hians (Hedw.) Sande Lac. On log. Berrien Co.: Berrien Springs (22301).

Eurhynchium pulchellum (Hedw.) Jenn. On soil. Berrien Co.: Berrien Springs (22322). Kalamazoo Co.: Kellogg Forest (Halbert 208).

Eurhynchium pulchellum var. *praecox* (Hedw.) Dix. On soil. Kalamazoo Co.: Kellogg Forest (21905, 21924).

Rhynchostegium serrulatum (Hedw.) Jaeg. and Sauerb. On soil and decaying logs. Barry Co.: Hardwood Swamp (22243). Berrien Co.: Warren Woods (22287). Kalamazoo Co.: Kellogg Forest (21931).

ENTODONTACEAE

Entodon cladorrhizans (Hedw.) C. Müll. On rocks and decaying wood. Barry Co.: Glass Creek (22133, 22168). Shiawassee Co.: Rose Lake (Halbert 1231).

Entodon seductrix (Hedw.) C. Müll. On logs and rocks. Barry Co.: Glass Creek (22144). Berrien Co.: Warren Woods (22262). Eaton Co.: Grand Ledge (22386). Shiawassee Co.: Rose Lake (Halbert 793).

PLAGIOTHECIACEAE

Isopterygium deplanatum (Sull.) Grout. On log. Berrien Co.: Berrien Springs (22307).

Plagiothecium denticulatum (Hedw.) B. S. G. On moist soil and logs. Barry Co.: Otis Lake (22104). Kalamazoo Co.: Kellogg Bird Sanctuary (21961). Mason Co.: Ludington State Park (22026). Shiawassee Co.: Rose Lake (Halbert 66).

Plagiothecium laetum B. S. G. On decaying wood and soil. Barry Co.: Glass Creek (22159). Kalamazoo Co.: Kellogg Bird Sanctuary (21955). Mason Co.: Ludington State Park (22007).

Plagiothecium roeseanum B. S. G. On soil. Barry Co.: Glass Creek (22145). Berrien Co.: Warren Woods (22289, 22308). Shiawassee Co.: Rose Lake (Halbert 794).

SEMATOPHYLLACEAE

Brotherella recurvans (Michx.) Fleisch. On humus and tree bases. Barry Co.: Otis Lake (22114). Mason Co.: Ludington State Park (22037).

Heterophyllium haldanianum (Grev.) Kindb. On soil, humus, and logs. Barry Co.: Otis Lake (22105). Berrien Co.: Warren Woods (22275). Eaton Co.: Grand Ledge (22357). Ingham Co.: Wooded deciduous swamp (Halbert 10). Kalamazoo Co.: Kellogg Forest (21908). Mason Co.: Ludington State Park (22008).

Sematophyllum carolinianum (C. Müll.) Britt. On sandstone. Eaton Co.: Grand Ledge (22393).

HYPNACEAE

Ctenidium molluscum (Schimp.) Mitt. On soil. Berrien Co.: Berrien Springs (22314).

Homomallium adnatum (Hedw.) Broth. On sandstone. Barry Co.: Glass Creek (22158). Kalamazoo Co.: Kellogg Forest (Halbert 206).

Hypnum curvifolium Hedw. On rocks and logs. Barry Co.: Glass Creek (22148). Shiawassee Co.: Rose Lake (Halbert 776).

Hypnum imponens Hedw. On log. Mason Co.: Ludington State Park (22024). Shiawassee Co.: Rose Lake (Halbert 9).

Hypnum lindbergii Mitt. On soil and logs in wet places. Barry Co.: Glass Creek (22125). Berrien Co.: Warren Woods (22283). Kalamazoo Co.: Kellogg Forest (21895). Mason Co.: Ludington State Park (22032).

Hypnum pallescens (Hedw.) P. Beauv. On rocks and logs. Barry Co.: Otis Lake (22115). Kalamazoo Co.: Kellogg Forest (21926). Mason Co.: Ludington State Park (22033).

Hypnum pratense Koch ex Spruce. On humus. Barry Co.: Hardwood Swamp (22249). Shiawassee Co.: Rose Lake (Halbert 1232).

Platygyrium repens (Brid.) B. S. G. On tree trunks, logs, and rocks. Barry Co.: Sager Road (22097). Berrien Co.: Warren Woods (22285). Eaton Co.: Grand Ledge (22388). Kalamazoo Co.: Kellogg Biological Station (22200). Shiawassee Co.: Rose Lake (Halbert 4).

HYLOCOMIACEAE

Rhytidiadelphus triquetrus (Hedw.) Warnst. On soil. Kalamazoo Co.: Kellogg Forest (21910).

BUXBAUMIACEAE

Diphyscium foliosum (Hedw.) Mohr. On soil. Barry Co.: Glass Creek (22164).

POLYTRICHACEAE

Atrichum angustatum (Brid.) B. S. G. On soil. Barry Co.: Glass Creek (22146). Berrien Co.: Warren Woods (22272). Kalamazoo Co.: Kellogg Forest (21899).

Atrichum undulatum (Hedw.) P. Beauv. On moist soil. Berrien Co.: Berrien Springs (22296). Kalamazoo Co.: Kellogg Forest (21897).

Polytrichum commune Hedw. On soil and humus. Kalamazoo Co.: Kellogg Forest (21912). Mason Co.: Ludington State Park (22036).

Polytrichum juniperinum Hedw. var. *alpestre* B. S. G. On humus. Barry Co.: Purdy Lake (22229). Kalamazoo Co.: Larix Bog (21945).

Polytrichum ohioense Ren. & Card. On soil. Berrien Co.: Warren Woods (22280). Mason Co.: Ludington State Park (22015).

Polytrichum piliferum Hedw. On sandy soil. Kalamazoo Co.: Larix Bog (21947). Mason Co.: Ludington State Park (22014).

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SPECIES OF VASCULAR PLANTS OF PENNFIELD BOG, CALHOUN COUNTY, MICHIGAN

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Recently a description and ecological analysis (Crow, 1969a) and a phytogeographical treatment (Crow, 1969b) of Pennfield Bog were presented. A listing of the species of vascular plants of the bog is now given to complete the documentation.

A total of 144 species of vascular plants were collected in the bog. Collections were made during the period of mid-April to mid-October, 1967. Voucher specimens are deposited in the Michigan State University Herbarium. Collection numbers are those of Crow.

The families are named and delimited after Gleason and Cronquist (1963) for pteridophytes and gymnosperms and Takhtajan (1966) for angiosperms. They are listed here in alphabetical order.

The occurrence of each species in the vegetation zones of the bog is indicated by a code in parentheses following the collection numbers. The zone in which the species is most frequent is listed first. The zones are those presented in the ecological analysis and vegetation map (Crow, 1969a).

D	*Decodon* zone
C-V	*Carex-Vaccinium macrocarpon* zone
C	*Cassandra* zone
C-T	*Cassandra-Thelypteris* zone
oL	open *Larix* subzone
L	*Larix* zone
L-S	*Larix-Salix* subzone
A	*Acer rubrum* zone
A*	outer margin of *Acer rubrum* zone
V	*Vaccinium corymbosum* subzone
N-E	*Nuphar-Eleocharis* zone
oW	open water of lake

LIST OF SPECIES

Aceraceae

Acer rubrum L. 157. (A, L, C-V).

Alismataceae

Alisma plantago-aquatica var. *americanum* Roem. & Schult. 320, 400, 420. (A*, openings of L).

Sagittaria latifolia Willd. var. *latifolia* 136, 325, 347, 511. (oL, C-V, L-S).

Anacardiaceae

Toxicodendron vernix (L.) Ktze. 132, 515. (Throughout the bog).

Apiaceae

Hydrocotyle umbellata L. 191, 350, 507. (Infrequent, on slightly submerged edges of floating islands associated with D).

Sium suave Walt. 382, 497, 507. (D, C-V, C-T, A*).

Aquifoliaceae

Ilex verticillata (L.) Gray var. *verticillata* 169, 408. (A).

Nemopanthus mucronata (L.) Trel. 60, 170, 276, 335. (A, L).

Araceae

Calla palustris L. 137, 156, 237, 516. (L, A).

Araliaceae

Aralia nudicaulis L. 483. (A*).

Asclepiadaceae

Asclepias incarnata L. subsp. *incarnata* 203, 523. (D, C-V, C).

Asteraceae

Aster junciformis Rydb. 517. (C-V).

A. umbellatus Mill. 410. (A*).

Bidens cernua L. 513, 518, 555. (A*, light shade of L-S).

B. coronata (L.) Britt. 197. 423, 426, 493, 558. (A*, C-V).

Eupatorium perfoliatum L. var. *perfoliatum* 389, 409, 536. (C-V, A*).

E. purpureum L. 388, 534. (C-T, C-V).

Balsaminaceae

Impatiens biflora Walt. 387, 399. (A*).

Betulaceae

Betula lutea Michx. f. 77, 90, (A).

B. pumila var. *glabra* Regel 75, 290. (L-S).

Corylus americana Walt. 542. (A, one station).

Campanulaceae

Campanula aparinoides Pursh var. *aparinoides* 201, 280. (C-V, D, C-T).

Caprifoliaceae

Sambucus canadensis L. 234. (A*).

Viburnum lentago L. 492. (A*).

Ceratophyllaceae

Ceratophyllum demersum L. 428. (oW).

Cornaceae

Cornus stolonifera Michx. 72, 192, 288, 345. (L-S, A).

Cucurbitaceae

Echinocystis lobata (Michx.) T. & G. 418. (A*).

Cyperaceae

Carex aquatilis Wahl. 84, 194, 286, 293. (C-V, L-S).

C. canescens var. *disjuncta* Fern. 152, 195. (C-V, L-S).

C. chordorrhiza L. f. 158, 161. (D).
C. comosa Boott 143, 274, 327, 521. (D, N-E).
C. interior Bailey 159, 221, 369. (L, C-V).
C. lasiocarpa var. *americana* Fern. 142, 223, 227. (C-V, C-T).
C. trisperma Dew. 226, 367. (L, A).
Cyperus diandrus Torr. 398, 508. (D, one station).
C. engelmanni Steud. 393, 505. (C-V).
Dulichium arundinaceum (L.) Britt. 224, 381. (N-E, C-V, oL).
Eleocharis compressa Sull. 95. (C-V).
E. intermedia (Muhl.) Schultes 396, 509. (D, two stations).
E. smallii Britt. 147, 149, 209, 429. (N-E).
Eriophorum gracile Koch 93, 151, 222. (N-E, C-V).
E. virginicum L. 213, 329, 331. (oL, C).
Rhynchospora alba (L.) Vahl. 331, 535. (C-V, oL).
Scirpus acutus Muhl. 193. (S-L).
S. cyperinus (L.) Kunth 332, 385. (oL).

Droseraceae

Drosera intermedia Hayne 266, 318, 355. (C-V).
D. rotundifolia L. 319, 354. (C, D).

Ericaceae

Andromeda glaucophylla Link. 54, 63, 189, 239. (C-V, oL).
Cassandra calyculata (L.) D. Don 42, 188, 240, 295. (C, C-T, D, L-S, oL). [*Chamaedaphne* incorrect name. See Wood (1961).]
Gaultheria procumbens L. 376. (A, one station).
Vaccinium corymbosum L. 69, 92, 153, 363. (L, A, V).
V. macrocarpon Ait. 36, 134, 238. (C-V, oL, C).

Equisetaceae

Equisetum fluviatile L. 51, 199. (L-S, L).

Fabaceae

Apios americana Medic. 365, 531. (L).

Fagaceae

Quercus velutina Lam. 278. (L, A).

Haloragaceae

Myriophyllum verticillatum L. 56, 183, 230, 352, 561. (oW).

Hypericaceae

Hypericum boreale (Britt.) Bickn. 308, 357, 504. (C-V).
Triadenum virginicum (L.) Raf. 307, 390, 406. (C-V, D, L-S).

Iridaceae

Iris versicolor L. 411. (A*).

Juncaceae

Juncus brevicaudatus (Engelm.) Fern. 384, 503. (N-E).
J. effusus var. *solutus* Fern. & Wieg. 214, 330. (oL).

Juncaginaceae

Triglochin maritima L. 340, 557. (C-V, two stations).

Lamiaceae

Lycopus uniflorus Michx. 341, 343, 359, 484, 520, 537. (N-E, D, C-V, L).
Scutellaria galericulata L. 133, 202, 281, 404, 539. (C-V, C-T).
S. lateriflora L. 391, 405, 482. (D, A*).

Lemnaceae

Lemna minor L. 356. (Rare, in pools in C-V).
L. trisulca L. 228. (L, one station).

Lentibulariaceae

Utricularia gibba L. 397, 506. (Infrequent, on slightly submerged edges of floating islands associated with D).
U. intermedia Hayne 139, 268b. (C-V).
U. purpurea Walt. 233, 269, 525. (oW).
U. vulgaris L. 57, 104, 247, 268a, 533. (oW, N-E).

Liliaceae

Maianthemum canadense Desf. var. *canadense* 81, 207, 244b, 272. (A).
M. canadense var. *interius* Fern. 164, 187, 206, 244a, 538. (A).

Lythraceae

Decodon verticillatus (L.) Ell. var. *verticillatus* 314, 328. (D).

Menyanthaceae

Menyanthes trifoliata L. 71, 163. (oL, C-V, L-S).

Monotropaceae

Monotropa uniflora L. 186, 323, 512. (L).

Nymphaeaceae

Brasenia schreberi Gmel. 184, 527, 559. (oW).
Nuphar luteum subsp. *macrophyllum* (Small) Beal 140, 528. (C-V).
Nymphaea tuberosa Paine 138. (N-E, oW).

Nyssaceae

Nyssa sylvatica Marsh. 360, 427, 492. (A, L, only two stations noted).

Onagraceae

Epilobium strictum Muhl. 338, 358, 480. (C-V, A*).

Orchidaceae

Cypripedium acaule Ait. 70, 273, 334. (L, oL).
Habenaria ciliaris (L.) R. Br. 312, 530. (oL).
H. clavellata (Michx.) Spreng. 321, 478. (A).
H. obtusata (Banks ex Pursh) Rich. 324. (oL).
Isotria verticillata (Willd.) Raf. 100. (L).
Liparis loeselii (L.) Rich. 166, 348. (C-V, L-S).
Malaxis monophyllos var. *brachypoda* (Gray) F. Morris 336. (C-V).
Pogonia ophioglossoides (L.) Ker. 141, 337. (C-V).

Osmundaceae

Osmunda cinnamomea L. 146, 235, 368. (A).
O. regalis var. *spectabilis* (Willd.) Gray 144, 242

Pinaceae

Larix laricina (DuRoi) K. Koch 35, 236. (L, C, C-T, C-V).
Pinus strobus L. 91. (L, A, two large trees, seedlings rare).

Poaceae

Agrostis stolonifera var. *major* (Gaud.) Farw. 150, 211, 279, 292. (L).
Glyceria canadensis (Michx.) Trin. 210, 419. (L).
G. striata (Lam.) Hitchc. 401. (A*).
Leersia oryzoides (L.) Sw. 501. (A*).
Muhlenbergia racemosa (Michx.) BSP. 342, 414, 522. (C-V).

Polygonaceae

Polygonum hydropiperoides Michx. var. *hydropiperoides* 313, 353, 383. (In open water just off edge of *Decodon* mat).
P. sagittatum L. 514. (A*).
Rumex orbiculatus Gray 519. (L-S, one station).

Polypodiaceae

Onoclea sensibilis L. 386, 488. (A, C-V).
Thelypteris palustris var. *pubescens* (Laws.) Fern. 339. (C-V, C-T, D, A).
Woodwardia virginica (L.) Smith 271, 315. (oL).

Pontederiaceae

Pontederia cordata L. 145, 168, 241, 407. (N-E, C-V).

Potamogetonaceae

Potamogeton gramineus L. 218, 220, 349, 529. (N-E, C-V).
P. illinoensis Morong 182. (oW).
P. natans L. 181, 185, 246, 526, 560. (oW).

Primulaceae

Lysimachia thyrsiflora L. 101, 554. (D).
Trientalis borealis Raf. 76, 232, 245. (L, A).

Ranunculaceae

Coptis trifolia var. *groenlandica* (Oeder) Fass. 65, 510. (A).
Ranunculus sceleratus L. 562. (L-S, one station).

Rosaceae

Amelanchier arborea (Michx. f.) Fern. 33, 374. (A).
Aronia melanocarpa (Michx.) Ell. 82, 362, 496. (V, A, L).
Potentilla palustris (L.) Scop. 103, 135, 282. (D, C, oL).
Prunus virginiana L. 88. (A*, one station).
Rosa palustris Marsh. 73, 297. (Margin of L and D, A, L-S).
Rubus hispidus var. *obovalis* (Michx.) Fern. 167, 208, 277, 364, 417. (L, A).
R. pubescens Raf. 83. (L-S, one station).
Spiraea alba DuRoi 283, 289, 344, 361, 489. (C-V, C-T, oL, L-S, A*).
S. tomentosa L. 283, 326, 532. (D, C-V, C-T, L).

Rubiaceae

Cephalanthus occidentalis L. var. *occidentalis* 296, 333, 416. (D).
Galium trifidum L. var. *trifidum* 231, 242b, 284, 415. (C-V, L-S, A*).
Mitchella repens L. 375. (A, one station).

Salicaceae

Populus tremuloides Michx. 79, 285. (C-V, V).
Salix bebbiana Sarg. 52, 291, 492. (L-S).
S. candida Flügge 38, 39, 40, 86. (Margin of C-V and L).
S. pedicellaris var. *hypoglauca* Fern. 41, 55, 59, 154, 216. (C-V).
S. petiolaris Sm. 37, 370. (C-V, L-S, D).
S. serissima (Bailey) Fern. 87, 89. (C-V, C).

Sarraceniaceae

Sarracenia purpurea L. 64, 131, 366. (C-V, C, oL).

Saxifragaceae

Ribes americanum Mill. 200, 549. (L-S, one station).
R. hirtellum Michx. 541. (L-S, one station).

Scrophulariaceae

Agalinis purpurea (L.) Pennell 329, 486. (C). [*Gerardia* misapplied. *Agalinis* is the conserved name (Lanjouw, et al., 1966, p. 336).]

Solanaceae

Solanum dulcamara L. 180. (C-T, one station).

Sparganiaceae

Sparganium chlorocarpum var. *acaule* (Beeby) Fern. 229, 380. (N-E).
S. minimum (Hartm.) Fries 351. (oW at edge of D).

Typhaceae

Typha latifolia L. 267. (D, C-T).

Ulmaceae

Ulmus rubra Muhl. 198, 217. (A, L).

Urticaceae

Boehmeria cylindrica (L.) Sw. 205, 287, 346, 540. (C-V, L-S, A).
Urtica dioica var. *procera* (Muhl.) Wedd. 556. (A*).

Violaceae

Viola affinis LeConte 85. (A*, one station).
V. nephrophylla Greene 322, 394, 524. (C-V, C, D).

Vitaceae

Parthenocissus quinquefolia (L.) Planch. 494. (A*).
Vitis vulpina L. 498. (A*, one station).

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THE LOG FERN (*DRYOPTERIS CELSA*) AND ITS HYBRIDS IN MICHIGAN—A PRELIMINARY REPORT

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BACKGROUND

The woodferns, *Dryopteris,* are conspicuous plants in the pteridophyte flora of the eastern United States. Large, robust plants with massive and scaly rhizomes, many of the woodferns are showy and ideal for cultivation in shaded gardens. They are notorious for their tendency to cross and form vigorous hybrids, and indeed woodfern hybrids may become common to abundant in certain localities. The presence of these plants, more or less intermediate in appearance between the parent species, has resulted in much taxonomic confusion. The same entity has been variously interpreted as a species, as a variety of another species, or as a hybrid.

Fortunately the development of techniques for cytological analysis, and the duplication of wild hybrids by experimental hybridization, have gradually brought an understanding of the basic relationships within the genus in the last two decades. For the benefit of those readers who are not familiar with this "genome analysis" approach we will briefly review the current knowledge of the woodferns of eastern North America.

The basic building blocks, as they might be called, are the genomes of the diploid species, in which there are two duplicate, compatible sets of 41 chromosomes each. For convenience, these basic sets are identified by a kind of shorthand in which the initial of the specific epithet is used to designate the genome, as G for goldiana, L for ludoviciana, M for marginalis, etc., with the letter appearing once for each set of this genome. Thus the giant woodfern, *Dryopteris goldiana,* is GG. In a few cases, hybrids of the basic species have somehow managed to double their chromosome sets, as in *D. celsa,* GGLL.

The discovery of natural crosses between these plants with doubled chromosome complements and other species provides a means for determining what basic sets or building block genomes are present in such polyploid species and in what proportions they are present. Thus our continuing search for natural hybrids of the various woodferns is a search for additional links in the chain of evidence by which we can analyze the phylogenetic development of the various species. Of the approximately three dozen distinguishable kinds of *Dryopteris* in the eastern United States, in fact, only 12 are fertile, sexual plants with normal spores and prothallia. All of the rest are sterile, unbalanced hybrids, with non-matching sets of chromosomes. For example, our common "Boott's woodfern," *Dryopteris* X*boottii,* is the natural hybrid of "crested fern," *D. cristata,* with the cytogenetic formula SSLL, and "fancy fern," *D. intermedia,* with the formula II. The hybrid may be formed from a sperm

with the formula SL and an egg with I, so that *D.* X*boottii* will have the formula SLI. The chromosomes of set S cannot pair with those of L, nor L with I, nor I with S. The individual chromosomes of one set do not pair properly in spore formation with those of the other sets, and the chromosomes are thus distributed with great irregularity and in such imbalance that all of the spores tend to be abortive and inviable. The plant is therefore sterile.

On the contrary, the fertile woodferns, as shown in the diagram in Figure 1, do have balanced genomes which pair normally and produce living spores. In *D. spinulosa,* which has four complements of chromosomes, there are two sets of I chromosomes and two sets of S. The I chromosomes pair with each other, and the S chromosomes do likewise, so that all of the spores receive the IS constitution.

In research on *Dryopteris* we are thus able to determine relationships to a large extent by observing how the chromosomes pair at the time of spore production. We can tell that *D. campyloptera,* the "mountain woodfern," shares a genome with *D. intermedia* by studying their hybrid. This cross, DDII X II, produces a triploid DII, in which we find two complements of chromosomes neatly paired (i.e., two sets of I) and one set completely unpaired (i.e., D). Since the basic number of chromosomes per set or genome in *Dryopteris* is $X = 41$, we see 41 pairs and 41 singles in the hybrid of *D. campyloptera* and *D. intermedia.* By combining studies of morphology and ecology of the plants with observations of their chromosomes, it is possible to work out an objective scheme of relationships, as shown in Figure 1.

The summary of fertile kinds of woodferns shown in this figure results largely from the basic work of Stanley Walker of the Department of Genetics, University of Liverpool (1955, 1961, 1962), who studied the interrelationships of eastern American *Dryopteris* taxa as well as those in Europe. In connection with our own cytofloristic investigations of ferns, especially in Michigan, Virginia, and New York, we have supplemented Walker's work with numerous additional observations. The summary in Figure 1 shows that *D. filix-mas* and *D. marginalis* are not related to the others, according to chromosome data. Taxa #3 through #12, however, are connected with each other through shared genomes. One of the fertile woodferns, which we have designated "*D. semicristata,*" is still only a hypothetical plant, not yet discovered. The postulated plant may be extinct or it may still exist, but it will resemble *D. cristata* or the hybrid *D.* X*uliginosa* (= *D. cristata* X *spinulosa*) so closely that it may be overlooked. It probably differs subtly from *D. cristata* in having slightly more dentate margins and more divided leaflets.

There are still other problems. For example, we are not certain that *D. campyloptera* is really DDII (Wagner, 1963). Our only evidence for the D genome in this fern is the discovery of *D. campyloptera*-like plants in the Huron Mountain area of Michigan in company with *D. intermedia* and what we have called "Lake Superior *D. dilatata,*" which we regard as possibly an undescribed species. The *campyloptera*-like plants were hybrids of *D. intermedia* and Lake Superior *dilatata* and they were sterile, with little or no

pairing at meiosis. We interpreted their cytogenetic constitution to be DI, which, if doubled, would produce the fertile tetraploid DDII (Wagner and Hagenah, 1962). Widén and Sorsa (1968) have recently contributed new data from chemical studies of the spreading woodfern of the Lake Superior region. These show striking differences from the spreading woodfern of the western United States and Europe, *D. assimilis,* which is a similar-appearing diploid. In the words of these authors, "Our results . . . fit in with the view of Wagner and Hagenah (1962) that the 'western diploid' and the 'Lake Superior diploid' are separate species rather than with the opinion of Britton (1967) that they are conspecific."

CLINTON'S WOODFERN AND THE LOG FERN

Two of the swamp-inhabiting taxa, *D. clintoniana* and *D. celsa,* are noted for their close similarities. In general, fortunately, they do not occur together. Plants from New England to the western Great Lakes area are the former, known as "Clinton's woodfern"; and plants from approximately New Jersey southward are the latter, the "Log Fern," which was originally

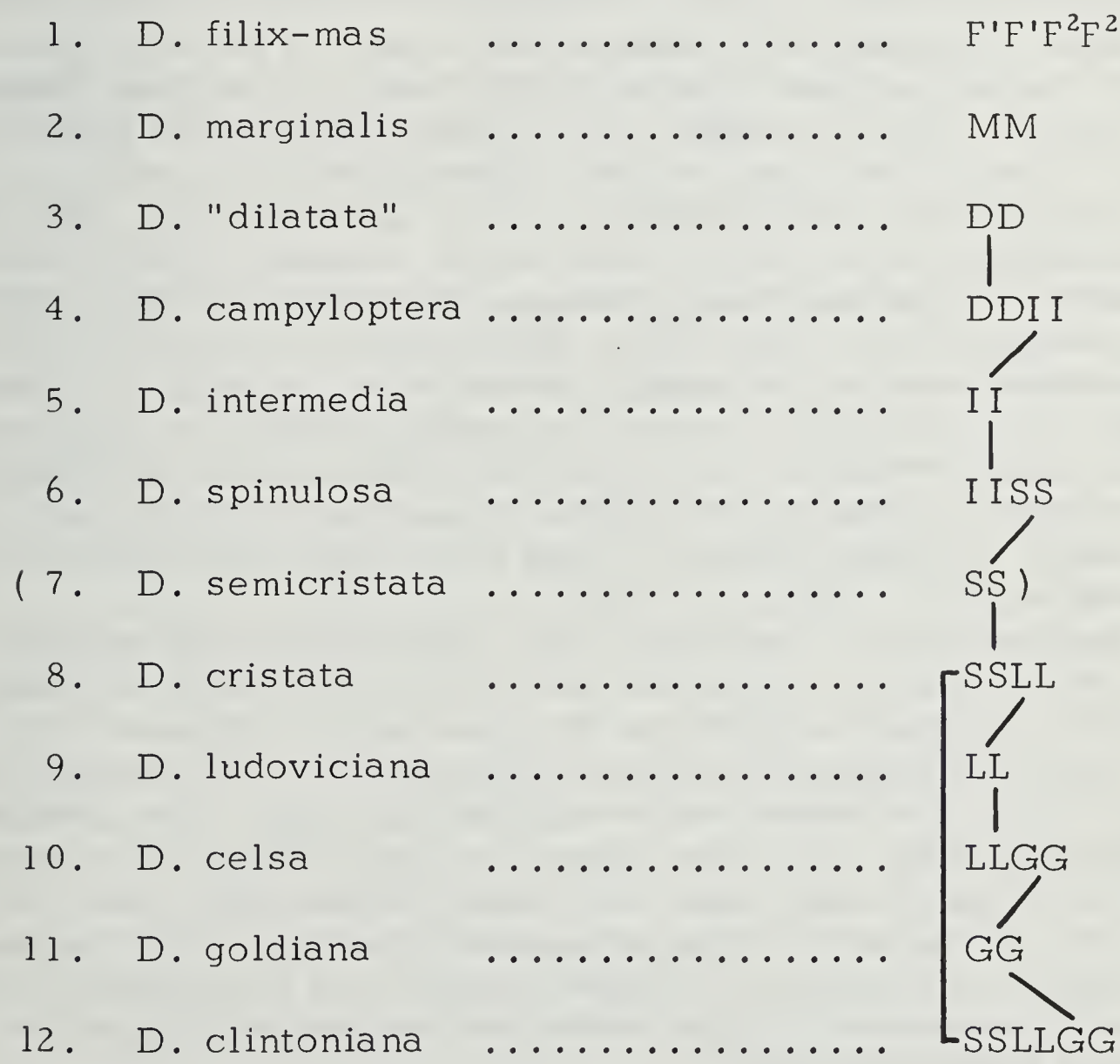

Fig. 1. Fertile (sexual) cytomorphotypes in the woodferns, Dryopteris, of eastern United States, exclusive of *D. fragrans.* The evidence for the existence of taxon #7 is entirely inductive; it has not yet been discovered as a living plant.

described from plants growing on logs and at the bases of tree-trunks in Dismal Swamp, in Coastal Plain Virginia.

Dryopteris clintoniana is one of the most interesting members of the woodfern complex because it has the highest chromosome number. It is hexaploid with the genomic constitution SSLLGG, a total of 246 chromosomes. Its hybrids with *D. cristata* are pentaploid with the formula SSLLG, thus showing 82 pairs and 41 singles at meiosis. Its hybrids with *D. goldiana* are tetraploid, i.e., SLGG, with 41 pairs and 82 univalents at meiosis. Clinton's woodfern is very common in appropriate habitats in southern Michigan. It flourishes in rich, wet, shady swamps, where it is often accompanied by *D. cristata* and *D. goldiana* and readily forms hybrids with them. As a result of this hybridization we find a gradient series of ferns that run from the narrow, pale-scaled *D. cristata* to the broad, black-scaled *D. goldiana,* i.e., SSLL-SSLLG*-SSLLGG-SLGG*-GG. (Sterile hybrids in the series here and below are marked with an asterisk.) Obviously, considering the natural variability of the plants involved, such a series can be very confusing to the collector.

We have never expected to find log fern in Michigan. Indeed, in view of our present difficulties of making identifications of the more critical hybrids we have always congratulated ourselves that we were so far from its known range to the south and east. If, in fact, log fern did grow in southern Michigan in the area of Clinton's woodfern, we would have the formidable potentiality of a bewildering and subtle cytomorphological series, i.e., SSLL-SSLLG*-SLLG*-SSLLGG-SLLGG*-SLGG*-LLGG-LGG*-GG! And this does not include all of the *D. cristata* and *D. clintoniana* hybrids with *D. marginalis, D. intermedia,* and *D. spinulosa*–hybrids which are already known from Michigan: MSL*, ISL*, ISSL*, MSLG*, ISLG*, and ISSLG*. These known hybrids more or less resemble members of the foregoing list in various respects. If *D. celsa* should also exist in the state, then three more confusing hybrids could potentially occur, namely MGL*, IGL*, and ISGL* (Cf. illustration in Wagner and Wagner, 1965). Thus if *D. celsa* were to occur in our area, the number of possible members of this group would jump from 11 to a disheartening 18.

Dryopteris celsa is very similar to *D. clintoniana* in gross appearance. The latter is so like *D. cristata* that some authors (e.g., Fernald, 1950) have treated it as a broad-fronded variety, viz. *D. cristata* var. *clintoniana.* In general *D. celsa* can be distinguished from *D. clintoniana* on the following characters: basal leaflets broader, more ovate-lanceolate (rather than triangular), midrib slightly scaly (rather than glabrous or nearly so), and scales on the rhizomes and petiole bases darker and glossier (blackish rather than brown or tan). Also, the spores of *D. celsa* average smaller than those of *D. clintoniana,* being only 35 to 45 microns in longest diameter rather than between 45 and 50. The chromosomes of *D. celsa* number 164, but those of *D. clintoniana,* as mentioned above, number 246.

The extent of *D. celsa* northward along the Atlantic coastal region is still not well established, but there is evidence of its occurrence, at least in the past, to as far as Staten Island, New York. Plants which have sometimes been

identified as *D. clintoniana* from eastern Pennsylvania to South Carolina and Louisiana north to Arkansas and Missouri have all proved to be *D. celsa.* Log fern is a rare and sporadic plant, but may be locally abundant in appropriate habitats. Recently we discovered disjunct populations of it in the vicinity of Rochester, New York, isolated over 200 miles from the nearest other localities in the southeast and growing well within the territory of *D. clintoniana.* With the single exception of the Rochester occurrences of *D. celsa* we had absolutely no reason to anticipate finding it in Michigan.

Readers may well imagine our astonishment, therefore, to discover that *D. celsa* and at least a couple of its hybrids do grow in Michigan—over 400 air miles from the nearest other known localities in Rochester, N. Y., and over 450 miles from its localities in Missouri. One can picture, from what has been stated above, the multiple problems that this discovery will present, with respect not only to the origin of the Michigan populations, but also to the inherent difficulties we expect to face in our future explorations, when we encounter all of its potential hybrids.

CIRCUMSTANCES OF THE DISCOVERY

On December 1, 1968, W. H. Wagner and D. J. Hagenah explored two localities in Kalamazoo County, Michigan, each a large swamp dominated by black ash, *Fraxinus nigra,* yellow birch, *Betula lutea,* and American elm, *Ulmus americana,* the latter largely dead or dying from Dutch elm disease. The first swamp we visited was on the north side of Section 20, along W Avenue (T4S, R12W—Prairie Ronde Tp.), the second in the northeast quarter of Section 6 (T4S, R11W—Schoolcraft Tp.), near Sugarloaf Lake. The former of these localities was mentioned earlier by Wagner and Chen (1965) as an excellent woodfern locality which we strongly recommended to students of *Dryopteris.* The second locality, unfortunately, is in the process of being destroyed. Around the base of the "Island," a wooded knoll in the middle of the swamp, the ferns in question were exceedingly abundant, but now the knoll (as shown on the left in Figure 2) is nearly cleared except for a few large trees, and the swamp (on the right) is scheduled to be cleared, probably in spring and summer of 1969. In a short time the whole area will be a housing development.

On this date, we encountered a large number of luxuriant woodferns that appeared to be either *Dryopteris clintoniana* X *goldiana* (SLGG*) or the similar *D. celsa* X *goldiana* (LGG*). We found plants of this type at both localities, and they so suspiciously resembled the plants of *D. celsa* X *goldiana* we had studied from Rochester and from Staten Island, New York, and from Tennessee, that we took a rather large sample of rhizomes for later cytological investigation, as well as some plants of different morphology growing near by.

The plants in question were potted and grown in a research greenhouse at the University of Michigan Botanical Gardens by Donald Trout. By February, the new fronds had become large enough to begin spore production, at which time their chromosomes could be studied. F. S. Wagner surveyed the plants cytologically, discovering that indeed our supposition was correct—the

plants did conform cytologically to *D. celsa* X *goldiana,* with the pairing behavior of LGG, showing 41 pairs and 41 singles. One of the parents, therefore, had to be *D. celsa.* Fortunately among the plants in our sample we had taken one which superficially resembled *D. clintoniana* except for its dark scales and somewhat broader, and less triangular pinnae. This specimen proved to be the predicted *D. celsa,* displaying 82 normal pairs at meiosis. Another plant which resembled *D. clintoniana* X *cristata* in the field proved to be *D. celsa* X *cristata,* showing dark scales and SLLG chromosome pairing behavior, 41 pairs and 82 singles.

Both of these log fern hybrids are remarkably similar to their other parents, and we feel certain that at least some plants previously identified from the Kalamazoo area as *D. goldiana* were in fact *D. celsa* X *goldiana.* The central plant in the profiles of living leaves (Fig. 3) shows the narrow blade

Fig. 2. Winter view of swamp where *Dryopteris celsa* and its hybrids are abundant. This locality will soon be destroyed for a housing development. (Photograph by Terry L. Sharik.)

and short petiole of the hybrid *D. celsa* X *cristata*. Note especially the "Venetian blind" arrangement of the pinnae, those except at the tip twisted into a plane almost parallel to the ground. *Dryopteris celsa* X *goldiana* (profiles to either side in fig. 3), on the other hand, shows little of this pinna orientation. Its very broad blades and long petioles are but little different from those of the giant woodfern, *D. goldiana*. Both of these hybrids, though sexually sterile, are extremely attractive and vigorous, and they may give promise horticulturally.

Subsequent investigations, still incomplete, in the herbaria of University of Michigan, Western Michigan University, and Michigan State University, indicate that there are probably other localities in Kalamazoo County and in nearby Allegan County. Plants heretofore identified from this area as *"D. clintoniana," "D. cristata,"* or *"D. goldiana"* are likely to be *D. celsa* or its hybrids. On the basis of what we know now, we strongly suspect that all of the hybrids described above will ultimately be found in southwestern

Fig. 3. Profiles of living fronds of log fern hybrids: *Dryopteris celsa* X *goldiana* on both sides. *D. celsa* X *cristata* in middle. Note the distinctive pinna orientation, narrow blades, and short petioles of *D. celsa* X *cristata*. (Photograph by James P. Bennett.)

Michigan. In the following list of potential new taxa in our flora, those which have already been demonstrated are marked with a dagger:

†Dryopteris celsa . . . . . LLGG
D. Xleedsii (= D. celsa X marginalis) . . . . . MLG*
D. Xseparabilis (= D. celsa X intermedia) . . . . . ILG*
D. celsa X spinulosa . . . . . ISLG*
†D. celsa X cristata . . . . . SLLG*
†D. celsa X goldiana . . . . . LGG*
D. celsa X clintoniana . . . . . SLLGG*

DISCUSSION

If all of the above woodfern taxa are found in the near future, the total number of known species and hybrids of pteridophytes in the state of Michigan will be increased to 122 from Hagenah's 1968 (unpublished) total of 115. Three of them were actually collected, as reported here, so the total is presently 118. For those botanists in Michigan who are appalled at the prospect of identification of these plants, we hope that as our further investigations of the woodfern swamps of Kalamazoo and nearby counties move ahead we shall finally be able to construct a reliable key to differentiate all of the taxa discussed here. At the present time no such key exists.

The range extensions represented here are striking. Over four hundred miles from the nearest known localities to the east and southwest, the discovery of log ferns in this state is very remarkable. This is the third one of the pteridophytes now known in Michigan that occur only in the southwestern portion of the state and which constitute major disjunctions. Many years ago Liberty Hyde Bailey encountered stands of the narrow chainfern, *Woodwardia areolata,* in Van Buren County (cf. Billington, 1952, p. 209). Richard W. Pippen in 1966 reported that a population of the American climbing fern, *Lygodium palmatum,* grows in Kalamazoo County, not far from the finds described here of the log fern. Is there something distinctive about this area which permits southern and coastal plain plants to occur at long distances from their major ranges? (Cf. Hanes, 1942)

In conclusion, we should point out that our *"Dryopteris celsa"* could possibly represent a different cytotype from the typical plants of the south. It has occurred to us that the northern plants might actually involve a different genome from true *D. celsa,* making it possible for it to grow in the main range of *D. cristata, D. spinulosa,* and *D. clintoniana,* all plants of the higher latitudes. One hypothesis might be that instead of our *"D. celsa"* being an amphidiploid of the southern woodfern, *D. ludoviciana* (LL) and the giant woodfern, *D. goldiana* (GG), it could have arisen as the amphidiploid of the unknown woodfern, *D. semicristata* (SS), and giant woodfern. Its formula would then be SSGG. We must remember, however, that the existence of *D. semicristata* is still a purely hypothetical conjecture itself, and as our studies continue we may be forced to conclude that there was or is no such plant, past or present. The postulation of such a plant as *D. semicristata* is simply the only means we have at present of explaining the currently available facts.

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News of Botanists

Dr. Eric A. Bourdo, Jr., Director of the Ford Forestry Center of Michigan Technological University, has been named the first dean of that University's new School of Forestry and Wood Products, which includes the Department of Forestry, the Institute of Wood Research, and the Ford Forestry Center.

Recent deaths of former University of Michigan botanists include Dr. Edwin B. Mains (Director of the Herbarium 1931-1960), on December 23, 1968; Dr. Bessie B. Kanouse (Curator of Fungi in the Herbarium, 1926-1960), on January 28, 1969; and Dr. Felix G. Gustafson (plant physiologist in the Department of Botany since 1920, retiring as Professor in 1959), on January 13, 1969.

Dr. Frederick K. Sparrow, appointed Director of the University of Michigan Biological Station for the three years until his retirement, was one of two recipients of annual Merit Awards from the Botanical Society of America at its 1968 annual meeting.

MARCHANTIA POLYMORPHA IN NORTHERN MICHIGAN

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Certain of the variations of *Marchantia polymorpha* L. have not been sufficiently taken into account in northern Michigan or in North America as a whole. Because of a background of experience with the various expressions of this species in other parts of the world, I made a special attempt in the summer of 1968 to study its diversity in the general vicinity of the University of Michigan Biological Station, in northern Michigan, where colonies resembling the var. *polymorpha* and others resembling the var. *aquatica* Nees are found.

Marchantia polymorpha is very widely distributed and varies considerably according to environmental conditions (Burgeff, 1943; Maravolo & Voth, 1966; Voth, 1941, 1943; Voth & Hamner, 1940). Nees (1838) characterized the variations known to him according to the left-hand side of the following outline; for purposes of comparison the subdivision used in this paper is given on the right-hand side.

M. polymorpha L.

_____ var. *aquatica* Nees

A. communis
  α. aquatica
    α 1. nuda *α* 1*. brevipedunculata
    α 2. denticulata *α*2*. brevipedunculata
    α 3. lobulata
  β. riparia
    β 1. dilatata *β* 1*. latissima
    β 2. angusta

_____ var. *polymorpha*

  γ. domestica
    γ 1. receptaculis grandiusculis
    γ 2. receptaculis minutis

_____ var. *alpestris* Nees

B. alpestris
  B*. crispa
    B *β*. riparia
    B *γ*. domestica
      B *γ* 1. macrophylla
      B *γ* 2. microphylla

Müller (1906-11), in dealing with the liverworts of Germany, Austria, and Switzerland, reduced Nees' confusing array of taxa to three, namely *M.*

polymorpha (corresponding to A. *communis* γ . *domestica* Nees) and the forma *aquatica* (including A. *communis* α. *aquatica* Nees and β. *riparia* Nees) and *alpestris* (equating with B. *alpestris* Nees and its variations). It is this view of the species as a whole that is presented (at the varietal level) in this paper. Müller also recognized the forma *mamillata* Hagen, which has not been generally accepted by other authors, for, as Evans (1917) states, "it is based on exceedingly vague characters." Müller, in a later publication (1951-58), treated his forms as varieties.

The essential features of *Marchantia polymorpha* are well known from accounts in textbooks of botany. Should goblet-shaped gemma cups be present on the upper surface of a flat, forking thallus, the plant is immediately recognizable as a *Marchantia. Marchantia polymorpha* typically has ventral scales in several rows (at least three) on each side of the midline, with the outermost projecting beyond the thallus edge. In this respect it differs from both *Preissia quadrata* (Scop.) Nees and *Conocephalum conicum* (L.) Dum., which in northern Michigan grow in situations somewhat similar to those where *Marchantia* is found but have median scales only. In the upper part of the thallus are air chambers containing photosynthetic filaments and opening to the exterior by barrel-shaped pores which contrast with the simple pores of *Conocephalum.* When gametophores are present, *Marchantia* is easily recognized by the characteristic shapes of the male and female receptacles.

Descriptions of the var. *aquatica* are given by many authors, including Nees (1838), Macvicar (1912; 1926), and Burgeff (1943). From their accounts we can conclude that the characteristic features of var. *aquatica* are the thin thallus showing little branching, the sunken, dark median line where air chambers are lacking, the poorly developed ventral scales, and in some instances infrequent occurrence of gemma cups and gametophores. The diagnostic features of the var. *alpestris* (not particularly pertinent to the present discussion) are well set out by Warncke (1968).

There is considerable evidence that var. *aquatica* and var. *alpestris* differ from var. *polymorpha* in other than morphological features. Burgeff (1943), as a result of extensive cultural and genetic studies, concluded that the three taxa warrant specific rank. Cytological work on Burgeff's material was carried out by Haupt (1932), who reported that although these taxa all have the same haploid chromosome number of 9 (8 + m), the m (or sex) chromosome of female plants of var. *polymorpha* is four times the mass of that in male plants; but in var. *aquatica* and var. *alpestris* the sex chromosomes are of an equivalent size in both male and female plants. Material from Michigan, cultured and treated according to the method described by Haupt, gave comparable results, although observed differences were slight, owing to the minute size of the chromosomes. (This included female material of var. *polymorpha* collected by M. Frohlich in Benzie County and male material of the same collected by H. Crum in Presque Isle County, as well as male and female material of var. *aquatica* collected by the author in Cheboygan County.) Biochemically, also, the var. *aquatica* may be distinct, for Tucker (1963) reported that the thallus contains a specific antigenic protein in contrast to that found

in var. *polymorpha.* In range of distribution, the three varieties often overlap, although it has been shown that var. *aquatica* alone has become established in glass houses and shade houses within recent years in New Zealand (Campbell, 1969) and that var. *alpestris* is tolerant of high concentrations of copper and other heavy metals (Warncke, 1968).

Living material of *M. polymorpha* var. *polymorpha* was collected in northern Michigan by D. Vitt in Luce County, from a sandstone bluff near Upper Tahquamenon Falls; by M. Frohlich in Benzie County, between Platte River and Goose Road underneath the steps of a cabin built in 1957 on a filled area in a *Thuja* swamp; and by H. Crum in Presque Isle County, 1.5 miles northwest of Mast Point on U. S. Highway 23, on the banks of a roadside ditch. The thallus is green to yellow-green and has air chambers over its entire width. On the upper surface, polygonal areas are evident because of the colorless, or nearly colorless, partitions between air chambers. The pores are normally open but become closed when the thallus is immersed in glycerol, indicating that they are functional. On the under surface, the scales are well developed and in several rows. The median scales carry appendages which are often made conspicuous by a magenta coloring in their cell walls. This color may be present in the scales and the flat portion of the thallus, as well. Rhizoids are most abundant and often brown in color. No gemma cups were found, but some thalli bore antheridiophores, others archegoniophores with maturing sporogonia.

Comparable specimens in the Herbarium of the University of Michigan (MICH) or of the Biological Station (UMBS) include the following:

CHEBOYGAN CO. Bryants Bog, on burnt ground, *C. M. Roberts,* 1921 (UMBS). MACKINAC CO. Bois Blanc Island, *Frances Wynne,* 1942 (UMBS); Mackinac Island, burnt soil near lime kiln, Lime Kiln Trail, *N. G. Miller,* 1965 (UMBS, MICH). DELTA CO. Northeast part of Summer Island, among sedges on damp organic debris over limestone pavement, *N. G. Miller,* 1968 (UMBS, MICH).—All these specimens had either gemma cups or antheridiophores or archegoniophores.

Plants representative of the var. *aquatica* were found growing in mats in the seepage pools and streamlets bordering Carp Creek, in the vicinity of the Iron Bridge. The thallus is submerged or likely to be submerged at times of high water, is dark-green in color and thin in texture. Air chambers are normally present except at the very dark midline which shows up with its lack of air chambers as a prominent feature of the upper surface; only in a few totally submerged colonies was a suppression of air chambers over the entire width of the thallus observed. In no plants are polygonal areas corresponding to the air chambers conspicuous, for the partitions between the air chambers, like the filaments within the chambers, contain many chloroplasts. The pores are normally closed but may open in air of high humidity (as in a plastic bag), only to close again immediately if the thallus is immersed in glycerol, showing that they are responsive to turgor changes. On the lower surface the scales are poorly developed. However, more particularly near the growing apices, median scales with appendiages are usually observable, and in places at the edge of the thallus small marginal scales generally can be seen, usually

projecting somewhat. Multiplication of thalli is chiefly from fragmentation, for gemma cups are infrequent or absent, and although in some colonies antheridiophores or archegoniophores are found, rarely are any sporogonia present. Adjustment to drier conditions by submerged forms is too slow for survival, since plants stranded when the water dries up in summer were seen to die away. In this way, many colonies are obliterated, but, provided that the dry period is not too extended, adventitious shoots may develop ventrally from the midline region and eventually re-establish the colony.

The following specimens are considered to be comparable:

CHEBOYGAN CO. Reeses Bog, *Frances Wynne,* 1942 (UMBS); Iron Bridge, Carp Creek, on wet soil, *Margaret Fulford,* 1951 (UMBS). LUCE CO. Upper Tahquamenon Falls, *H. Crum & N. G. Miller,* 1966 (UMBS). ALPENA CO. Growing over *Drepanocladus uncinatus* at bottom of a sink hole, *N. G. Miller,* 1968 (UMBS).

It would seem that *M. polymorpha* var. *polymorpha* is the plant which grew as extensive colonies on burnt-over areas at the time when burning of bog and forest was a regular practice in northern Michigan (Nichols, 1922; Gates, 1942). Roadbanks and old campfire sites were also favored locations for this variety (Fulford, personal communication). Now, with fewer fires and road construction of a different type, not leaving wet, shady spots favorable to *Marchantia*, only a few habitats are left available to it, such as limestone rocks and some swampy areas.

Although it is true that var. *aquatica* is not always sharply distinct from the many forms of var. *polymorpha,* it is, in its usual form, strikingly different and easily recognized. For this and other reasons mentioned above, it seems useful and appropriate to recognize it at the varietal level. It grows in particularly wet situations and is at times completely submerged. Judging from specimens in the liverwort herbarium of the American Bryological Society at the University of Cincinnati, the North American distribution of var. *aquatica* is predominantly northeastern, in a circle around the Great Lakes including Ontario, Nova Scotia, Pennsylvania, Wisconsin, and Minnesota, and northwestern, in Oregon, Washington, Alberta, and Montana; but it is also known from the High Plains of Nebraska (at 3120 ft.) and in New Mexico (at 8500 ft.).

ACKNOWLEDGMENTS

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Review

NATURAL AREAS IN INDIANA AND THEIR PRESERVATION. By Alton A. Lindsey, Damian V. Schmelz, & Stanley A. Nichols. The Report of the Indiana Natural Areas Survey. Department of Biological Sciences, Purdue University, Lafayette, Indiana 47907. 1969. 594 pp.

Our neighbor to the south has produced a handsomely printed and bound report, magnificent in both concept and execution, which can elicit only praise and envy from other states. Members of the Michigan Natural Areas Council, which is engaged in a much more modest inventory of natural areas, will applaud the first 67 pages of background material on principles of preservation, the nature of this compendium, and the natural vegetation divisions and soils of Indiana. Cataloging of 162 areas follows. In addition to information on size, exact location (with directions where needed), ownership, priority for preservation, and general features of each area, there are often data on vegetation, site and vegetation maps, photographs (including sometimes stereopairs), and literature references. The volume concludes with the text of the 1967 act by the General Assembly of Indiana establishing a state system of nature preserves. Indiana residents and all others who share the same concerns will be profoundly grateful to the industrious authors of this survey and to the Ford Foundation, which financed their work 1967-1969.

–E. G. V.

BIOLOGY OF THE MOUSE-EAR CHICKWEED, *CERASTIUM VULGATUM*

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INTRODUCTION

The common Mouse-ear Chickweed, *Cerastium vulgatum* L. (Caryophyllaceae), has spread widely throughout the temperate and subtropical regions of the world, evidently as a result of features that make it especially successful in following human cultivation and disturbance of sites. This investigation of the plant's ecological life history endeavored to determine some of the attributes which have led to its great success as a weed.

The success of this species is due in part to pre-adaptation of its growth form, germination characteristics, and life cycle to the environmental conditions of the disturbed or cultivated areas which it colonizes; and in part to its large production of easily dispersed seeds, to its adventitious growth, and to the variability of its populations. I attempted to investigate these various aspects of the species. A few questions were resolved with adequate sampling and reliable results, but for other questions, only preliminary results were obtained under the conditions of the study.

The problem of nomenclature and circumscription of the species is unresolved at the moment due to an essentially worldwide distribution and possible hybridization. In Europe it is treated as *C. fontanum* Baumg. ssp. *triviale* (Link) Jalas (Tutin, 1964). It is identified here on the basis of characterization by Gleason (1963).

Plant materials used for the experiments came largely from seeds collected from lawn and border weed plants on the main campus of the University of Michigan and from lawn and old-field weed plants at the University Botanical Gardens, Ann Arbor. Except when stated to the contrary, all observations reported below are based on plants grown from these seed sources. In addition, collections of seed were made at nine localities across the United States and Canada in order to sample the regional variation of *C. vulgatum.* These nine seed sources with the dates of collection are:

1. Ridgewood, New Jersey; July 15, 1967
2. High Point, New Jersey; August 12, 1967
3. Madison, Wisconsin; June 25, 1967
4. Minneapolis, Minnesota; June 25, 1967
5. Iowa City, Iowa; July 12, 1967
6. Pine Bluffs, Wyoming; July 11, 1967
7. Nanaimo, British Columbia, Canada; July 2, 1967
8. Victoria, British Columbia, Canada; July 2, 1967
9. Olympia, Washington; July 4, 1967

All the plants were grown experimentally under uniform conditions of light and water on a soil composed of 50% washed sand, 25% sterilized humus-rich silt loam, and 25% perlite. None received artificial light.

MORPHOLOGY

C. vulgatum is a non-fleshy perennial herb with a prostrate pattern of growth resulting from weak stems and adventitious rooting at the nodes and infrequently at the internodes. Larger plants have a stem length of about 0.5 meters; the largest plant grown under glass in this study had a stem length of 0.57 m. The majority of plants studied had stem lengths of 0.1 to 0.2 meters. Some plants flowered at less than 0.18 m, although most plants usually had longer stems at time of flowering due to an elongation of internodes near the apex in preparation for flowering.

Most commonly the basic growth form consists of several long stems radiating from one central point, but this is often obscured by adventitious spreading of the plant. All the populations except the one from Pine Bluffs, Wyoming, exhibited this growth pattern. In contrast, the plants from Pine Bluffs had masses of tiny leaves growing around the point at which the roots entered the soil and on the few portions of branched stems. Since only 4% of the seed from Pine Bluffs germinated, it is not possible to assess the cause of this unusual form.

The leaves are opposite and have no stipules. They vary from oblong to ovate, taper at the apex, and are 1-3 cm long and 0.3-1.5 cm wide. The three West Coast populations sampled had leaves which were shorter and wider than the leaves of the other populations. Leaf variation may be divided into three categories for comparison:

A. Long and narrow (length/width $>$ 2.6/1): High Point, Madison (mixed with roundish), Minneapolis (many without the characteristic narrowing of the blade as it joins the stem), Iowa City, and Pine Bluffs.

B. Intermediate (length/width = 2.5/1): Nanaimo and Olympia.

C. Roundish (length/width $<$ 2.4/1): Victoria

The plant is covered with fine hairs. On the stem these hairs are of variable lengths and slant downward. The Madison plants had very little hair on the stems; those from Minneapolis and Victoria had very hairy stems. Most of the hair on the leaves is on the upper surfaces; the hair on the under surfaces lies along the veins and margins. The hairs on the leaves are multicellular and uniseriate. Leaves of plants from all regions were similar in hairiness, except those from High Point, which had very hairy leaves.

The plant bears its flowers toward shoot apices. The flowers are either solitary or terminal in dichotomous cymes. The mature pedicels are from 0.5 to 1.2 cm long (Gleason, 1963) and elongate as the fruit matures.

In a plant that was sectioned for observations of stem anatomy, there were nine collateral vascular bundles in a ring surrounding a pith cavity. Outside the vascular bundles were three layers of sclerenchyma cells in the cortex.

The outer cortex was chlorenchymatous and had more air spaces than cells. Although Korsmo (1954) has reported secondary growth in *C. arvense,* no evidence of secondary growth was seen in the plant studied.

Other external morphological characters of *C. vulgatum* are described in Gleason (1963). In addition, seedling morphology is treated in detail by Kummer (1951), the morphology of the flower is covered by Thompson (1942), and the morphology of the seed is discussed by Woodcock (1928).

From experimentation with four light levels—achieved by using 0, 1, 2, and 3 layers of dark green shade cloth over growing plants—it was found that *C. vulgatum* can grow under any of these light conditions but thrives in full sunlight. Four plants of uniform size, each in a separate 6-inch pot, were placed under each combination of shade cloth layers. After a period of fourteen weeks, the growth of the plants under all four light conditions was measured by fresh weight, overall length of stem, and number of nodes. Then, after drying the plants in an oven at about 68 C for one week, their dry weights were measured.

The results of the shade experiment are shown in the following table, in which the weights of plants from less shaded conditions are compared with those from the most shaded:

No. of Layers of Shade Cloth	Average Fresh Wt./Plant (grams)	Average Dry Wt./Plant (grams)	Comparative Weights	
			Fresh	Dry
3	0.32	0.063		
2	0.76	0.08	2.4X	1.3X
1	2.78	0.31	8.7X	4.9X
0	19.2	3.05	60.0X	48.6X

Obviously, growth is by far the greatest in full sunlight, at least under greenhouse conditions November through March. In addition, stem length (the sum of all the branching of the plant stem) is directly proportional to the weight before drying.

Individual plants under each shade layer did not necessarily have a correlation between increased length of stem and an increased number of nodes. For example, in full sunlight, one plant, which had flowered, had a greater number of nodes (395) for less stem length (400 cm) and fresh weight (21.75 g) than did another plant (with 345 nodes, length of 602 cm, and weight of 23 g) which had not flowered. Plants which flowered showed, in general, increase in both stem length and number of nodes. Average number of nodes is correlated with amount of light received and seems to be a simple index to amount of growth, as suggested by the following data:

No. of Layers of Shade Cloth	Average No. of Nodes/Plant
3	33
2	44
1	75
0	315

However, the average length of internode appears to be relatively constant or variable in response to some factors other than shade and amount of growth:

No. of Layers of Shade Cloth	Average Length of Internode
3	1.33 cm
2	0.96 cm
1	1.30 cm
0	1.40 cm

No firm conclusions may be drawn from these data on growth under different shade conditions. Under increased shade, elongation of internodes would be expected, but this is not supported by these experiments. The general observation that plants grown in full sun have longer internodes toward the apex compared to shade-grown plants is also not clearly supported.

The percentage of water in *C. vulgatum* varied from 80.0% to 90.4% based on measurements of water loss of each plant from each light environment after oven drying for one week. A low, anomalous figure of 60% was found for one of the plants grown under the three layers of shade cloth, but this was probably a result of an error in weighing the plant, since the plant had an extremely low weight. Disregarding this low figure, the average amount of water in the plants is 86.2% of the fresh weight.

Different shade intensities produced morphologic differences in the plants. The characteristics of the plants grown in full sun-light were larger leaves, denser pubescence, denser matting, more branching, and a darker shade of green compared to plants grown under the shade cloth. In addition to the above differences, shade plants had leaves with curling margins and roots that were weak and exposed above the soil surface. Although Kummer (1951) has described *C. vulgatum* as a plant primarily of shady areas, these results indicate that the best growth is made in full sun.

PHYSIOLOGICAL ASPECTS

On a temperature gradient germination plate with a range of 12-35 C, 38 seeds out of 112 seeds of *C. vulgatum* germinated in the range from 21-24 C. One seed germinated at 25 C.

Germination between wet paper towels at room temperature (24 C) was quite successful: on the fifth day, 24% had germinated; on the twelfth day, 56% had germinated; beyond this, germination was negligible.

Variation of percent germination of seeds from different regions could have resulted from any of several factors, including age and maturity of the seeds at the time of collection. Maturation of seed was undoubtedly under different environmental influences in the various regions where collections were made, but these could not be appraised. After cold, dry treatment, the seeds were planted under glass in November, with the following results:

Site (and No. of Seeds)	Germination Percentage
Ridgewood (60)	63%
High Point (85)	84%
Madison (35)	34%
Minneapolis (45)	81%

Site (and No. of Seeds)	Germination Percentage
Iowa City (100)	65%
Pine Bluffs (50)	4%
Nanaimo (10)	40%
Victoria (6)	40%
Olympia (10)	80%

Cold treatment for one week seemed to encourage faster germination and development, since at the end of three weeks 50% of the cold-treated seeds had germinated to seedling stage, while only 21% of the non-treated seeds had produced seedlings. Dry cold treatment, as opposed to wet cold stratification, produced the most seedlings; at the end of four weeks, 79% of the planted seed had developed. As more time elapsed, more seedlings appeared, as shown by the fact that at the end of six weeks, 62% of the planted non-treated seeds had produced seedlings.

Brett (1955) mentions that the seeds of *C. vulgatum* are viable after three or more years when stored in bags at room temperature and states results similar to those found here, such as the finding that cold treatment (two to three days at -2 C) hastened germination.

In my experiments, crowding of seeds when planted seemed to make little difference in the percentage of seedlings that appeared. Depth of planting was important, however (50 seeds planted at each depth):

Depth below Surface	Percentage Appearance
0	86%
0.5 cm	50%
1.0 cm	11%
2.0 cm	18%

Robbins, Crafts, and Raynor (1952) state that the seeds of chickweed germinate throughout the year. Furthermore, the seeds have only a short dormancy and thus germinate promptly after they are released from the dehisced capsule in the spring and summer.

Plants grown from seeds collected in Ridgewood, High Point, Minneapolis, and Iowa City grew more vigorously than plants from the other non-Michigan collections. The growth of plants from the Pine Bluffs and Olympia seed collections was distinctly less vigorous than the average growth of other non-Michigan samples.

A significant East-West gradient may be indicated by the presence of anthocyanin in the stem. No red color was present in the plants from Ridgewood seed, but the plants from High Point, Madison, and Minneapolis seed had bright red stems. Seed from the remaining localities (Iowa City and westward) produced plants with brownish stems. A distinct increase of anthocyanin in the stems of other *C. vulgatum* plants under greenhouse culture was noted starting with the week of February 3. This increase may have been due to increased periods or intensity of daylight.

Flowering appears to be related to the length of daylight received by the plants, since plants both fourteen weeks old and nine weeks old were

found to have opened flowers first on the same date (February 3). Plants that were germinated subsequently also flowered at nine weeks of age (March 29). It would seem that nine weeks is the (minimum?) age for flowering if light conditions are favorable. The fourteen-week-old plants produced more flowers than did the nine-week-old plants over a period of two months after the onset of flowering. As much as the apical third of a plant may be reproductive. After flowering and the formation of capsules are completed, the upper part of the plant turns yellow and dies. However, the plant is perennial from the basal parts of aerial shoots.

C. vulgatum reproduces both sexually, by either insect or self-pollination (Knuth, 1908), and asexually, by rooting adventitiously at the nodes and internodes. Adventitious rooting, at least at the nodes, can be induced by keeping a portion of the plant buried for some time; in this study rooting was effected by this technique in approximately two weeks. Cutting with a lawn mower stimulates the plant to a more vigorous prostrate growth (Fogg, 1945), primarily through increased branching and adventitious rooting.

C. vulgatum seems to have a basic chromosome number of 9. Chromosome counts of 72, 126, 144, and 180 have been taken (Index to Plant Chromosome Numbers, 1958).

BIOTIC INTERRELATIONSHIPS

Cerastium vulgatum is found in ecologically disturbed habitats such as old crop fields, newly abandoned fields, truck and flower gardens, mowed meadows, lawns, roadsides with fine-grained soils, naturally occurring alluvium, and slumping, earthen banks. The plants used in this study were found on silt-loam or clay-loam soils in well-watered lawns and fields, and along river banks.

Cows are known to eat the weed indiscriminately, encouraging matted growth; and dispersal of the seed by horses, reindeer, and birds is known. Furthermore, seeds of *C. vulgatum* can be dispersed by the wind, if the plants are in areas open to the wind (Ridley, 1930).

Insect pollination by long-tongued bees, short-tongued bees, other Hymenoptera, and Diptera has been observed (Robertson, 1929). The pollen, as reported by Edgeworth (1877), is subspheric with 6-12 pores and is approximately 33 microns in diameter.

C. vulgatum is susceptible to fungus diseases induced by species of Ascomycetes, Fungi Imperfecti, and Phycomycetes (von Tubeuf, 1897). In addition, it is susceptible to infection by a strain of tobacco-mosaic virus (Holmes, 1939). However, in my experience, diseased plants are uncommon.

ECONOMIC SIGNIFICANCE

Cerastium vulgatum is of economic significance only as a pest. It is an unattractive weed in grain fields, gardens, and lawns. Although the seeds are sometimes found in samples of grain (Harper, 1960), the dry biomass is small, so the plant is not a serious pest in this respect. The plant has no known toxic properties.

SUMMARY

In this preliminary description and analysis of *C. vulgatum,* plants from seeds from the vicinity of Ann Arbor were used for most observations. In addition, plants from seeds collected at nine localities on a mid-latitude traverse across North America were studied under uniform conditions and compared for presence of anthocyanin in the stems, hairiness, variation in percent germination, leaf variation, growth pattern, and growth vigor. No anthocyanin was seen in the plants from Ridgewood, whereas bright red pigment was seen in the plants from High Point, Madison, and Minneapolis, and the stems of the plants from Iowa westward were brownish. Leaves of the West Coast populations were shorter proportionately to width than were the leaves of other populations. No other characters varied consistently on a regional basis.

Using the seeds from Ann Arbor, a second experiment measured growth of plants under four different intensities of light. The results indicated that *C. vulgatum* grows best in full sunlight, at least under greenhouse conditions. Dry cold treatment was most effective in achieving early seed germination. Nine weeks is probably the minimum age of a plant before it flowers, given adequate intensities or duration of daylight. Reproduction is both asexual by adventitious rooting and sexual by insect and self-pollination.

ACKNOWLEDGMENTS

I wish to thank Dr. W. S. Benninghoff for his aid and encouragement and the University of Michigan Botanical Gardens for its help.

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AN UNUSUAL FRUITING OF *LEOTIA LUBRICA*

Florence V. Hoseney
Herbarium, The University of Michigan, Ann Arbor

Reluctance on my part to stop mushroom collecting for the season of 1968 led to the discovery of an unusual fruiting of *Leotia lubrica* Fr. It was found on a sandy hill which supported little vegetation except occasional scrub oaks, a few herbaceous flowering plants, and some mosses and lichens. Many interesting fungi have been found in this particular part of the Waterloo Recreation Area, Washtenaw Co., Michigan, and some curious habitat adjustments were observed. Among the species gathered late in 1968, partially or entirely covered by sand, were two large collections of *Pisolithus tinctorius,* some *Scleroderma geaster, Astreus hygrometricus, Cortinarius* sp., and *Leotia lubrica.* Some of these fungi are considered rare in Michigan.

Leotia lubrica was abundant during the normal fruiting season in 1968: so much so that one tended to disregard it when it was growing in its usual way. However the collection cited here was found late in the season (November 1) when few fleshy fungi were fruiting. The unusual dull green color and the fact that it grew buried in the sand were most irregular.

Preliminary microscopic study showed this to be *L. lubrica.* It possessed the same characteristics as the common *L. lubrica* which grows on humus or sandy soil. In the collection under discussion the fruit-bodies were fully matured but were still covered by the moist sand. Their presence was indicated by cracks in the sand. Only scattered caps were visible on the surface. Most fungous sporocarps when found below the surface of the soil are pallid and weakly pigmented. The pigment of these *L. lubrica* ascocarps was well developed even though most of the fruiting bodies were covered by about 2 cm of sand.

The overall height of the ascocarps (3.6-8.3 cm) plus the depth of the sand cover indicate that the point of origin is deep in the soil. Normally, ascocarps of *L. lubrica* appear on humus or sandy, barren soil, at the surface. This collection, therefore, is of considerable ecological interest.

The following is a description by Nancy Jane Smith of *Leotia lubrica* Fr. (*F. Hoseney 1170,* 1 Nov 1968, Waterloo Area, Washtenaw Co., Mich.):

Gregarious to cespitose in sandy area, predominantly hypogeous.

Pileus flattened, cushion-like, 0.6-0.8 cm high, 0.9-2.7 cm broad; hymenium smooth, dull olive green, margin curved under and the area sometimes exhibiting lobing; gelatinous when fresh.

Stipe 3.0-7.5 cm long, 0.4-1.2 cm in diam., terete to compressed with a vertical groove, slightly lubricous under the sand, pale olive green to a dull ochraceous color, green when underground and more yellow in older and emerged asocarps, macroscopically smooth.

Microscopic features:

Paraphyses filiform, typically slightly enlarged apically, straight, branching in the lower part.

Asci narrowly clavate, 8 spored, (134) 150-164 (203)μ X 8-9 (10.6)μ, not turning blue at the apex in Melzer's reagent.

Ascospores straight to slightly curved, narrowly ellipsoid to slightly allantoid (?) probably multiguttulate when fresh but the oil droplets coagulate when rehydrated after drying, (16.5) 18-22.5 (25.5)μ X (4) 4.5-5.2 (5.7)μ.

ACKNOWLEDGMENTS

I wish to thank Nancy Jane Smith for the description of the material and Dr. Alexander H. Smith for his encouragement and the photograph.

Fig. 1. *Leotia lubrica,* approximately natural size (Hoseney 1170).

MICHIGAN PLANTS IN PRINT

New Literature Relating to Michigan Botany

This section lists new literature relating to Michigan Botany under four categories: A. Maps, Soils, Geography, Geology (new maps and selected bulletins or articles on soils and geology as these may be of use to field naturalists and students of plant distribution); B. Books, Bulletins, etc., and C. Journal Articles (listing, respectively, all separate publications and articles in other periodicals which cite Michigan specimens or include research based on plants of wild origin in Michigan;–not generally including work on cultivated plants nor strictly economic aspects of forestry, conservation, or agriculture); D. History, Biography, Exploration (travels and lives of persons with Michigan botanical connections). When the subject matter or relation to Michigan is not clear from the title, annotations are added in brackets. Readers are urged to call to the editor's attention any titles (1960 or later) which appear to have been overlooked–especially in less well known sources.

A. MAPS, SOILS, GEOGRAPHY, GEOLOGY

Dutton, Carl E. 1968. Summary report on the geology and mineral resources of the Huron, Seney, Michigan Islands, Green Bay, and Gravel Island National Wildlife Refuges of Michigan and Wisconsin. U. S. Geol. Surv. Bull. 1260-I. 14 pp. $.20 [General geographical and topographical information for the areas, with conclusion that the mineral-resource potential is poor.]

Küchler, A. W., & Jack McCormick. 1967. Bibliography of vegetation maps of North America. Excerpta Botanica, Sec. B, 8: 145-289. [On pp. 215-224 are listed over 60 vegetation maps for Michigan or portions of the state (even small bogs)–some of them separately published and some in other publications. Titles are given, together with scale, but there are no annotations as to area covered (e.g., what is the "North Tip Block"?) nor kinds of features shown (e.g., that the Land Economic Survey cover maps show *size* categories, etc.). Arrangement is chronological by date represented by the vegetation mapped; there is an index to authors but not to counties or other geographic subdivisions.]

Küchler, A. W. 1967. Potential Natural Vegetation. National Atlas [of the U. S.] Sheet 90. U. S. Geol. Surv. $1.50. [Michigan, of course, is included, with 8 vegetation types. This is a revised edition, based on the author's 1964 larger scale map published by the Am. Geogr. Soc.; the small scale of this edition (1:7,500,000) provides a general picture but cannot be reliable for every tiny detail.]

Pregitzer, Karl E. 1968. Soil Survey of Muskegon County, Michigan. U. S. Dep. Agr. 95 pp. + 90 once-folded map plates + 5 folded tables and indexes. [As in other recent soil surveys, the map plates include complete aerial photography for the county at a scale of about 4″ = 1 mile, with boundaries of soil types overprinted. An indispensible field aid for anyone wanting quickly to survey the wooded and wild areas of the county. $5.50 from Govt. Printing Office, Washington 20402.]

U. S. Forest Service. 1968. Sylvania Recreation Area Management Plan, Ottawa National Forest. 47 pp. + 2 maps. [Indicates various management zones and the standards and facilities concerned with management of each. A major portion of this wild tract in Gogebic Co. is designated as a "Botanical Zone" (i.e., natural area) and much of the rest is a "Pioneer Zone."]

Zahner, Robert, & David R. Hedrich. 1966. Moisture release characteristics of forested sand entisols in northern Lower Michigan. Soil Sci. Am. Proc. 30: 646-649. [Variation in some moisture properties of Grayling sand under pine stands.]

B. BOOKS, BULLETINS, SEPARATE PUBLICATIONS

Brewer, Richard, Arlo Raim, & Jerome D. Robins. 1969. Vegetation of a Michigan Grassland and Thicket. Occas. Pap. Adams Ctr. Ecol. Stud. 18. 29 pp. [Map, tables,

photos, discussion reporting on the "Colony Farm Tract" within the city limits of Kalamazoo.]

Federal Committee on Research Natural Areas. 1968. A Directory of Research Natural Areas on Federal Lands of the United States of America. 129 pp. $.70 (Govt. Printing Office, Washington 20402). [Six areas in Michigan are included, with acreages in primary and other natural areas types. Exact locations are not given, only the county and Federal project–forest, park, refuge, etc.]

Shaffer, Robert L. 1968. Keys to Genera of Higher Fungi. ed. 2. Univ. Mich. Biol. Sta., Ann Arbor. 131 pp. $3.00. [Although the keys themselves include no locality data, the preface points out that they are designed primarily for Michigan students.]

C. JOURNAL ARTICLES

Barr, Margaret E. 1968. The Venturiaceae in North America. Canad. Jour. Bot. 46: 799-864. [Several species of these fungi are attributed to Michigan, rarely with more precise locality data. Includes keys, index to host plants.]

Boivin, Barnard. 1966. Études Ptéridologiques. III. Variations du Woodsia oregana. Bull. Soc. Bot. Fr. 113: 407-409. [Includes Keweenaw Peninsula and Porcupine Mts. in stated range of f. *cathcartiana,* and cities Porcupine Mt. collection of var. *squammosa (W. abbeae)* as an alleged extension of range (though cited in Billington's "Ferns of Michigan," 1952, pp. 145 & 224).]

Cain, Stanley A. 1967. Studies on the stemmed yellow violets of eastern North America II. Mass-collections of Viola pubescens and V. eriocarpa in the Michigan area. Nat. Canad. 94: 79-129. [Two of the collections studied were from Bruce Peninsula, Ontario; 18 were from Michigan, of which 11 were from Oakland Co.]

Crum, Howard. 1966. A taxonomic account of the genus Thelia. Natl. Mus. Canada Bull. 216: 123-127. [Michigan cited in the range of two of the three species of these mosses.]

Davis, H. A., Albert M. Fuller, & Tyreeca Davis. 1968. Contributions toward the revision of the Eubati of eastern North America III Flagellares. Castanea 33:206-241. [*R. flagellaris* said to range into Michigan. Michigan material is cited of *R. baileyanus* (including *R. tenuicaulis* & R. uvidus**), *R. plicatifolius* (including *R. exutus**), *R. roribaccus, R. meracus*, R. michiganensis** (including *R. complex** & *R. florenceae**), *R. vagus*, R. ithacanus, R. schoolcraftianus**, and *R. tantalus**, the last a stunted type perhaps referable to *R. meracus.* (Types of all names with asterisk are from Kalamazoo Co.) *R. peracer* (type locality in Cheboygan Co.) is referred to *R. multiformis.*]

Davis, Margaret B. 1968. Pollen grains in lake sediments: Redeposition caused by seasonal water circulation. Science 162: 796-799. [Studies done at Frains Lake, Washtenaw Co.]

Gaertner, A. M., & F. K. Sparrow, Jr. 1966. A preliminary study of aquatic Phycomycetes in the lakes of the Huron Mountains, Michigan. Veröff. Inst. Meeresforsch. Bremerhaven 10: 93-106.

Grund, D. W., & D. E. Stuntz. 1968. Nova Scotian Inocybes. I. Mycologia 60: 406-425. [Michigan collections, with localities, are cited for several of the species.]

Haard, Karen. "1968" [1969]. Taxonomic studies on the genus Arthrobotrys Corda. Mycologia 60: 1140-1159. [Much of the material studied was from northern Michigan localities.]

Harris, Betty D. 1968. Chromosome numbers and evolution in North American species of Linum. Am. Jour. Bot. 55: 1197-1204. [Includes count of n = 8 for *L. catharticum* from Chippewa Co.; generalized distribution maps of the L. cathartica complex and the virginiana and sulcata subgroups include Michigan.]

Hellum, A. K., & R. Zahner. 1966. The frond size of bracken fern on forested outwash sand in northern Lower Michigan. Soil Sci. Am. Proc. 30: 520-524. [Research done at Univ. of Mich. Biological Station. Size and density of fronds strongly influenced by soil profile and overstory forest cover.]

Iwatsuki, Zennoske, & Aaron J. Sharp. 1967. The bryogeographical relationships between eastern Asia and North America, I. Jour. Hattori Bot. Lab. 30: 152-170. [One

Michigan specimen (the type of *B. subcylindrica,* from Kalamazoo Co.) cited for *Buxbaumia minakatae.*]

Johnson, Robert G. 1968. Notes on the distribution of Disporum maculatum (Buckl.) Britton. Castanea 33: 262-266. [Cites Farwell's type of *D. cahnae* and includes dot in Oakland Co. in distribution map, but offers no explanation of this disjunct occurrence, merely asserting that "Farwell's meticulous description of the collection documents this as the northernmost known station for *D. maculatum.*" This is perhaps the first time in history that Farwell has been termed "meticulous."]

Knight, Allen W., & J. Whitfield Gibbons. 1968. Food of the painted turtle, Chrysemys picta, in a polluted river. Am. Midl. Nat. 80: 558-562. [Stomach contents of 46 turtles from Kalamazoo River included algae and higher aquatics, not named.]

Lippert, Byron E. 1967. Sexual reproduction in Closterium moniliferum and Closterium ehrenbergii. Jour. Phycol. 3: 182-198. [One of the strains of *C. moniliferum* included in this study of desmids came from near Levering in Emmet Co.]

Mickelson, Carol J., & Hugh H. Iltis. "1966" [1967]. Preliminary reports on the flora of Wisconsin No. 55 Compositae IV–Composite family IV (Tribes Helenieae and Anthemideae). Trans. Wis. Acad. 55: 187-222. [Map and discussion of range of *Tanacetum huronense* includes Michigan data; distribution maps for *Cirsium pumilum* ssp. *hillii* and *Besseya bullii* also include Michigan county distribution.]

Miller, Orson K., Jr. 1968. A revision of the genus Xeromphalina. Mycologia 60: 156-188. [Several of the species are cited from "Michigan," never with more precise locality.]

Reeder, John R., & D. N. Singh. 1967. Chromosome number in Calamovilfa. Bull. Torrey Bot. Club. 94: 199-200. [Count of 2n = 40 from *C. longifolia* var. *magna* grown at Yale from a clone collected at Warren Dunes State Park, Berrien Co.]

Smith, Alexander H., & Harry D. Thiers. 1968. Notes on Boletes–I 1. The generic position of Boletus subglabripes and Boletus chromapes 2. A comparison of four species of Tylopilus. Mycologia 60: 943-954. [Results from study of Michigan boletes; Part 2 includes description of *T. cyaneotinctus* from "Michigan."]

Strandhede, Sven-Olov. 1967. Eleocharis, subser. Eleocharis in North America. Taxonomical comments and chromosome numbers. Bot. Not. 120: 355-368. [Material of Michigan origin of *E. erythropoda* gave counts of 2n = 18 (Botanical Gardens, Ann Arbor) and 2n = 19 (Cheboygan Co.). Material of *E. smallii* sens. str. from Ingleside, Douglas Lake, gave count of 2n = 16; but an "unknown taxon" resembling *E. smallii* morphologically from Finster Marsh, Cheboygan Co., gave count of 2n = 36.]

Stuckey, Ronald L. 1968. Aquatic flowering plants new to the Erie Islands. Ohio Jour. Sci. 68: 180-187. [Includes summary of southeastern Michigan records for *Lycopus asper* and *Epilobium hirsutum.*]

Tessene, Melvern F. 1968. Preliminary reports on the flora of Wisconsin No. 59. Plantaginaceae–plantain family. Trans. Wis. Acad. 56: 281-313. [For a few of the species, brief comments are included on distribution or biology in Michigan.]

Thomas, Paul M., & Dennis D. Bromley. 1968. The establishment of aquatic vegetation in and around artificial fish shelters in Douglas Lake, Michigan. Am. Midl. Nat. 80: 550-554. [Concerns influence of 10 fish shelters constructed in 1937 on establishment of aquatic vascular plants and Chara.]

Ulken, Annemarie, & Frederick K. Sparrow, Jr. 1968. Estimation of chytrid propagules in Douglas Lake by the MPN-pollen grain method. Veröff. Inst. Meeresforsch. Bremerhaven 11: 83-88.

Wells, Virginia L., & Phyllis E. Kempton. 1968. Studies on the fleshy fungi of Alaska. II. Mycologia 60: 888-901. [*Psathyrella rigidipes* mentioned as frequently found in lawns at Ann Arbor, according to A. H. Smith.]

Wetzel, Robert G., & Don L. McGregor. 1968. Axenic culture and nutritional studies of aquatic macrophytes. Am. Midl. Nat. 80: 52-64. [Some of the *Chara* studied came from Barry Co.]

Yeatman, C. W. 1967. Biogeography of jack pine. Canad. Jour. Bot. 45: 2201-2211. [Chiefly on postglacial history of the species; includes reference to Michigan pollen profiles.]

Editorial Notes

The Editorial Board has approved a policy of modest payment for cover pictures. At least the cost of materials may be covered by the $5.00 now offered photographers. (Members of the Editorial Board and officers of the Michigan Botanical Club are ineligible for payment.) Good black and white prints suitable for cover pictures are earnestly solicited and may be submitted to the editor at any time.

Several defective copies of the March issue have been discovered, pages 68, 69, 88, & 89 being blank. Defective copies returned to the business manager will be promptly replaced.

The March number (Vol. 8, No. 2) was mailed March 7, 1969.

Program Notes

The state membership meeting of the Michigan Botanical Club was held March 16, 1969, at Nazareth College, Kalamazoo, with Dr. Elaine Hurst, head of the Biology Department, in charge of local arrangements. The new Southwestern Chapter was welcomed into the Club and was presented with a handsome charter. This chapter now has about 80 members. The officers (as pictured below, left to right) are Mrs. Helen Wiles, Parchment, Michigan, secretary; Dr. John Beaman, Michigan State University, vice president; Dr. Richard Pippen, Western Michigan University, president; and Dr. Harriette Bartoo, W. M. U., treasurer. The program included illustrated talks on Michigan wildflowers and early

spring fungi by Helen V. Smith and Dr. Alexander H. Smith. Several field trips were led to points of interest: the Nazareth College Ecology Center, by Dr. Hurst; a locality for the rare climbing fern, *Lygodium,* by Dr. Pippen; Kellogg Forest for early fungi, by Ellis Becker; the Audio-Tutorial Center for Biological Science at Western Michigan University, by Donna Schuman; the M. S. U. Biological Station at Gull Lake, by Peter Rich; and the Kalamazoo Nature Center, by Dr. Bartoo.

–Helen V. Smith

The Southeastern Chapter will hold its fall campout at Camp Kett (4-H), near Cadillac, October 3-5, 1969.

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(On the cover: Patterns in driftwood on the shore of Lake Superior at Whitefish Point, Michigan. Photographed July 20, 1967, by John S. Russell.)

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THE

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Articles and notes dealing with any phase of botany relating to the Upper Great Lakes Region may be sent to the editor in chief. The attention of authors preparing manuscripts is called to "Information for Authors" (Vol. 6, p. 202; reprints available from the editor).

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Membership in the Michigan Botanical Club is open to anyone interested in its aims: conservation of all native plants; education of the public to appreciate and preserve plant life; sponsorship of research and publication on the plant life of the State; sponsorship of legislation to promote the preservation of Michigan native flora and to establish suitable sanctuaries and natural areas; and cooperation in programs concerned with the wise use and conservation of all natural resources and scenic features.

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STUDIES OF THE BYRON BOG IN SOUTHWESTERN ONTARIO. XL. DISTRIBUTION OF *SPHAGNUM* MOSSES

William W. Judd
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The Byron Bog has been described by Judd (1957). It lies in a hollow at the southwest corner of Oxford Street and Hyde Park Sideroad in London, Ontario. There are three vegetation zones, A, B, and C (Fig. 1), in the bog. The central part is a mat of floating *Sphagnum* moss (Zone A). Surrounding this is an expanse of low woods, permanently damp or flooded (Zone B). In this zone *Sphagnum* grows beneath an overstory of shrubs. At its inner limits there are scattered black spruce and larch trees and at its outer limits are various deciduous trees. The outer rim of the bog consists of dry, wooded slopes (Zone C). In the floating bog is Redmond's Pond (D). Descriptions of the vegetation in the various zones include accounts of shrubs and vines (Judd, 1966), club-mosses and ferns (Judd, 1967), and orchids (Judd, 1968). In 1968 a study was made of the distribution of *Sphagnum* mosses in the bog.

METHODS

Sphagnum mosses were collected in the bog on October 6, 1968. Seven series of samples were taken by starting as close as possible to the edge of Redmond's Pond at seven points around the perimeter of the pond and walking outward in a straight line from each point to the limits of the *Sphagnum* growth. At regular intervals along the sample line, samples of mosses were taken, consisting of a handful of moss made up of the tips of fronds about three inches long. Along four of the sample lines five samples were taken and along three of the sample lines ten samples were taken, thus yielding fifty samples. In addition, fourteen samples were taken at the outer limits of *Sphagnum* growth where Zone B meets Zone C. The location of the sixty-four sampling points is shown by circles on the map (Fig. 1). The mosses were pressed lightly in newspaper until dry. They were identified by Dr. Howard Crum, Department of Botany, University of Michigan. Dr. Crum retained representative specimens for the University of Michigan Herbarium. Other specimens are deposited in the herbarium of the writer with accession numbers 738 to 750 as in the following account. Nine species and one variety were recognized and the distribution of them on the bog is shown on the map (Fig. 1). While most of the samples included only one species, some included two or three growing closely together.

ACCOUNT OF SPECIES COLLECTED

Sphagnum mosses formed the floating mat of Zone A and extended throughout Zone B where they grew on solid soil and formed cushions around the bases of larch and black spruce trees at the inner limits of Zone B. No *Sphagnum* grew on the wooded slopes of Zone C. The species collected are

discussed in order of decreasing numbers of samples, and the accession numbers of specimens in the writer's collection are included.

S. magellanicum Brid.—23 samples (744, 745, 747). This species is widely distributed in the bog, from the edge of Redmond's Pond to the outer limits of Zone B. The purple colour of the fronds, as described by Darlington (1964), was evident in the specimens. *S. magellanicum* is widely distributed in North America in bogs and has been reported from Michigan (Crum, 1964; Darlington, 1964), Indiana (Welch, 1957), and Pennsylvania (Jennings, 1951).

Fig. 1. Map of Byron Bog showing location of sampling sites for *Sphagnum* and distribution of species of *Sphagnum*.

A: Floating mat B: Low, damp woods C: Wooded slopes D: Redmond's Pond

S. recurvum P.-Beauv.—23 samples (739, 743, 747, 748). This species is widely distributed in the bog, from the edge of Redmond's Pond to the outer limits of Zone B. It is widely distributed in North America in bogs and has been reported from Michigan (Crum, 1964; Darlington, 1964) and Indiana (Welch, 1957). Jennings (1951) reports that it is the commonest species in Pennsylvania.

S. fimbriatum Wils. ex Hook.—20 samples (738, 750). This species is widely distributed in the bog, and is the species most commonly present in the shade of trees where Zone B meets Zone C. It is found over much of North America in bogs. It has been reported from Michigan (Darlington, 1964), Indiana (Welch, 1957), and Pennsylvania (Jennings, 1951).

S. capillaceum (Weiss) Schrank—16 samples (741, 744, 748). This species is widely distributed in the bog. It occurs over much of North America and has been reported from Michigan (Crum, 1964; Darlington, 1964), Indiana (Welch, 1957), and Pennsylvania (Jennings, 1951).

S. recurvum var. *tenue* Klinggr.—3 samples (747, 749, 750). All three samples of this moss were found in the shade of trees where Zone B and Zone C meet. This species is recorded by Darlington (1964) as occurring from Newfoundland to Pennsylvania and across the continent, and it has been recorded from Michigan (Darlington, 1964), Indiana (Welch, 1957), and Pennsylvania (Jennings, 1951).

S. centrale C. Jens.—2 samples (742, 746). These samples were found at the edge of Redmond's Pond. This species is widely distributed in North America. It is reported from Michigan (Crum, 1964; Darlington, 1964), but not from Indiana (Welch, 1957) or Pennsylvania (Jennings, 1951).

S. subsecundum Nees—1 sample (742). This moss was collected at the edge of Redmond's Pond. It is a species widely distributed in North America in bogs and has been recorded from Michigan (Crum, 1964; Darlington, 1964), Indiana (Welch, 1957), and Pennsylvania (Jennings, 1951).

S. teres (Schimp.) Ångstr. ex C. Hartm.—1 sample (740). This moss was found on the floating mat. It occurs in the northern part of North America southward to New Jersey and Michigan (Darlington, 1964) and has been reported from Pennsylvania (Jennings, 1951) but not Indiana (Welch, 1957).

S. papillosum Lindb.—1 sample (743). This species was collected from the floating mat. It occurs in the northern part of North America southward to New Jersey and the Great Lakes (Darlington, 1964) and has been reported from Michigan (Crum, 1964; Darlington, 1964) and Pennsylvania (Jennings, 1951), but not Indiana (Welch, 1957).

S. riparium Angstr.—1 sample (746). This was found at the edge of Redmond's Pond. It is a moss of the far north, i.e. Greenland, Labrador and Alaska (Andrews, 1915). It is rare in Michigan (personal communication, H. Crum, October 25, 1968) and has not been reported from Indiana (Welch, 1957) or Pennsylvania (Jennings, 1951).

The four species which are common and generally distributed in the bog, *S. magellanicum, fimbriatum, recurvum,* and *capillaceum,* are widely dis-

tributed in North America. *S. recurvum* var. *tenue* is generally distributed in North America and was found only in the shaded outer reaches of the bog. *S. papillosum* and *S. teres,* found only on the floating mat of moss, are species that occur in the northern part of North America. Of the three species found at the edge of the pond, *S. subsecundum* and *S. centrale* are found generally in North America and *S. riparium* is a moss of the northern part of the continent.

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POPULATION STUDIES IN THE CHEMICAL SPECIES OF THE *CLADONIA CHLOROPHAEA* GROUP[1]

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It has become increasingly popular in lichenology to stress characteristics based solely on chemical constituents rather than the traditional morphological features typical of plant systematics. The basis for chemical species formation is not clearly understood. The chemical differences are believed to be of genetic origin. However, the effects of habitat and substrate on the chemical nature of the podetia have not been extensively explored. Investigations with *Parmelia bolliana* (Hale, 1967) and *Cetraria ciliaris* (Graham, 1969) have indicated that the environment is not related to the cause of chemical

[1]Contribution from the Department of Botany, University of Michigan, and the University of Michigan Biological Station.

species formation. Zopf (1903) did find evidence of such a relationship with the environment in the *Pseudevernia* complex; however, similar results have not been extensive enough to justify any reliable, overall conclusions.

The *Cladonia chlorophaea* group consists of four chemical species each of which differs essentially by chemical constituents. The acid fumarprotocetraric is the only acid present in *Cladonia chlorophaea* (Flörke) Spreng. The other chemical species, which may or may not include fumarprotocetraric acid, are *C. cryptochlorophaea* Asah. containing cryptochlorophaeic acid, *C. grayi* Merr. containing grayanic acid, and *C. merochlorophaea* Asah. containing merochlorophaeic acid. *C. chlorophaea* ranges throughout the United States; *C. cryptochlorophaea* and *C. grayi* are widespread in the northeastern and midwestern portions of the country; and *C. merochlorophaea* occurs in the Great Lakes region and northern New England. These distinct ranges suggest taxonomic significance.

The purpose of this investigation was fourfold: First, to establish the percentage of each species within the total population in the vicinity of the University of Michigan Biological Station (Cheboygan County, Michigan). Second, to determine whether these percentages vary within any of the ecological communities tested. Third, to test for substrate specificity. Fourth, to determine whether there are morphological differences in the podetia of the various species.

At the beginning of the study I attempted to determine the relative size of a colony and thereby judge what should constitute a random sample. I chose a colony at or near the center of a clearing to act as a point of reference, and then took one podetia every inch up to one foot, and thereafter one podetium every foot along a transect of about 15 feet. After analysis I concluded that a population of *C. chlorophaea,* at least, extends over an area of almost 10 feet when podetia arise only from the soil. However, podetia taken from bark (usually but not always at the base of trees) within the same area

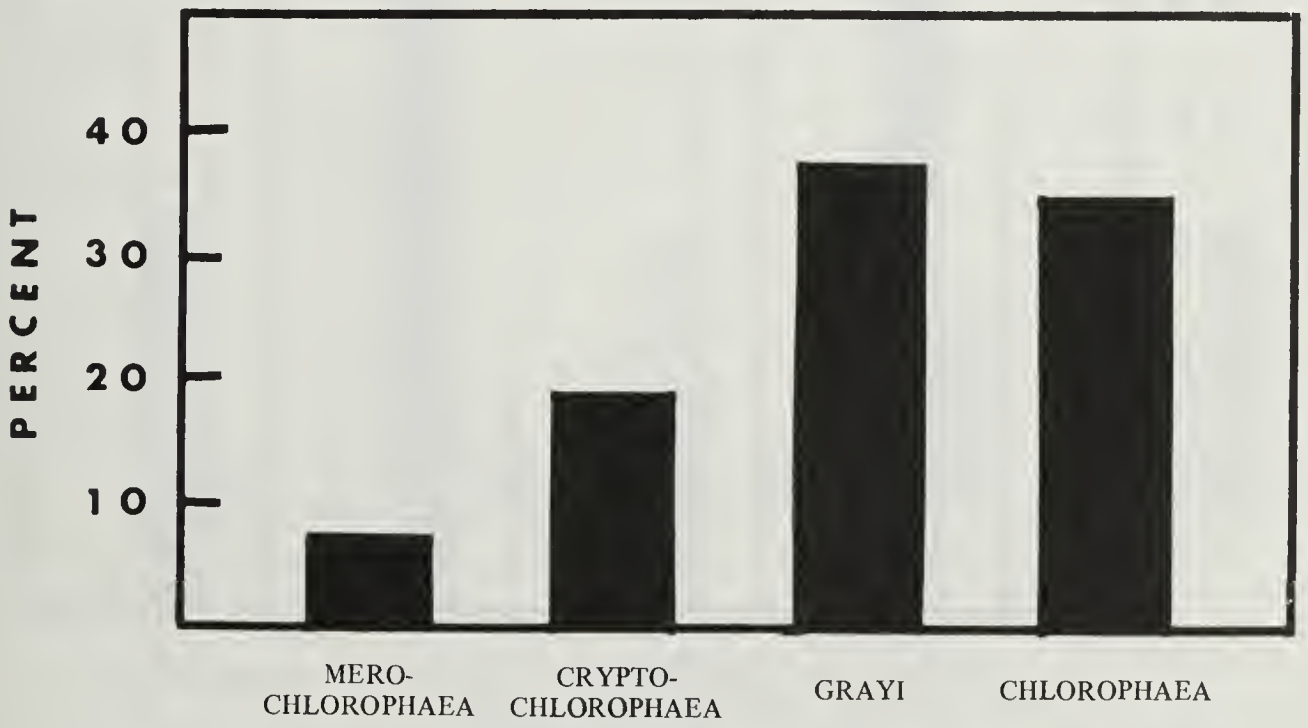

Fig. 1. Percentage of each species within the entire population studied.

typically belong to other members of the complex. Thus it was possible for two or more species to be within inches of each other. After repeating this procedure with similar results, I concluded that the remainder of my sampling could be accomplished by walking at least 10 feet before sampling again in a similar way, unless there was a suitable change in the substrate.

I sampled stands of bigtooth aspen (*Populus grandidentata*), red oak (*Quercus rubra*), jack pine (*Pinus banksiana*), and paper birch (*Betula papyrifera*). Twenty samples were taken at one time, half on soil and the other half on bark. Each sample was analyzed by crystalline tests and, at first, by thin-plate chromatography as well. (Later, chromatography was used only for occasional verification.) I then computed the percentages indicated in Figs. 1-3 and made morphological comparisons. The procedure for the crystaline test may be found in Hale (1961, p. 67).

The procedure for thin-layer chromatography was as follows: (1) Several closely adjacent podetia were placed on a numbered microscope slide and the acids extracted in acetone. (2) Numbered chromotographic plates cut to four

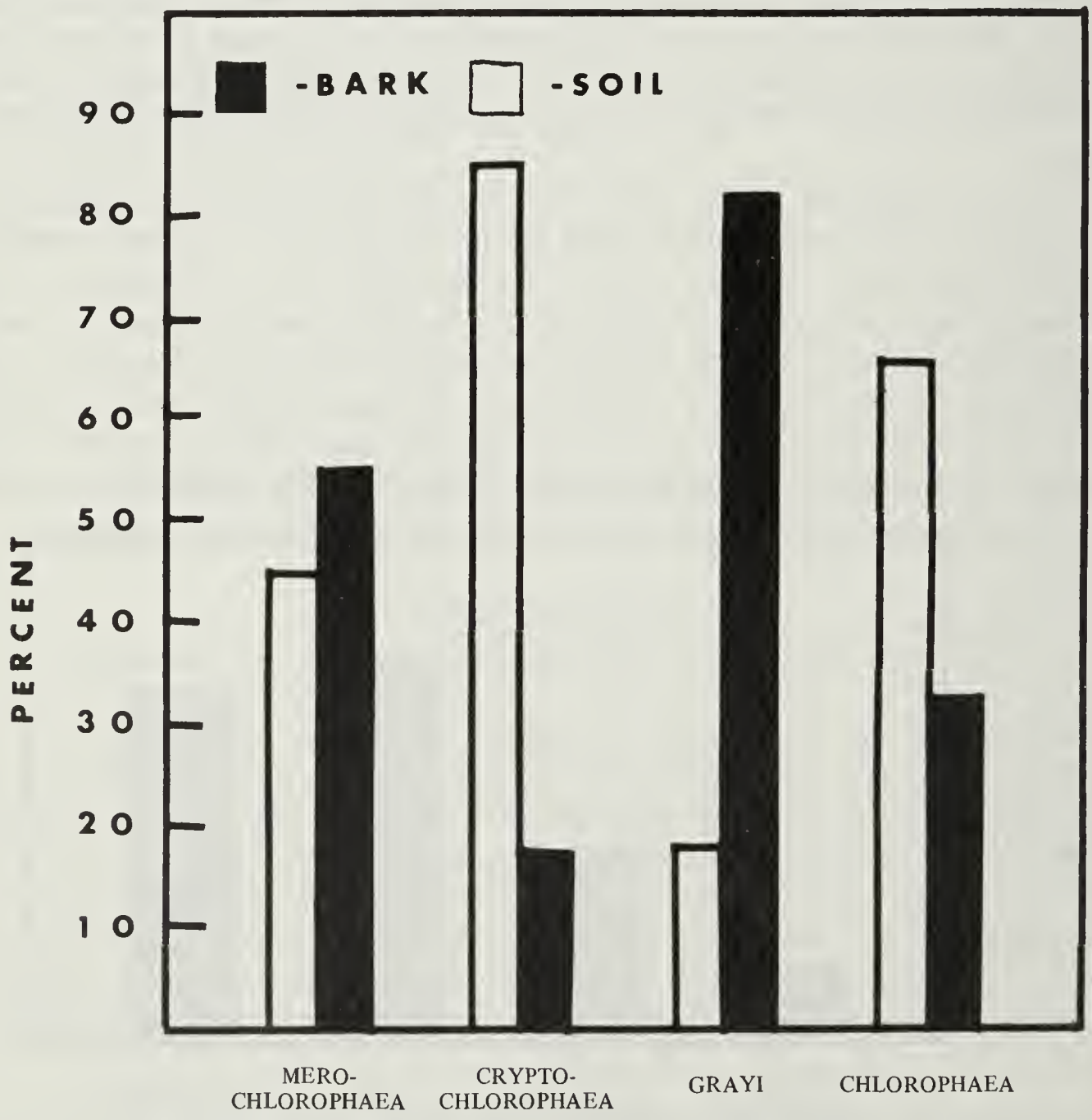

Fig. 2. Comparison of percentages of each species on soil and bark.

inches square were spotted with acid residue and transferred from the slide by micropipettes. (A concentrated spot, often taking several minutes of repeated application, worked best.) (3) The plates were then lowered into the chamber making sure that the residue was well above the level of the solvent. The plates were left in the chromatographic chamber for 30 minutes with a solvent mixture of benzene, p-dioxane, and acetic acid in the ratio of 4:6:1. (4) The acids, if present, made spots on the plate corresponding to known RF values. These were checked first with ultraviolet light, but a good percentage of the spots would not show up unless sprayed with a 5% normal solution of sulfuric acid and dried in a oven at 75° centigrade for 30 minutes. The RF values were then checked and crystalline tests performed when the results were inconclusive.

The percentage of each species within the entire population, as shown in Fig. 1, is based on 500 samples. Specificity as to substrate is indicated in Fig. 2. Though *C. merochlorophaea* did not show much preference, *C. cryptochlorophaea* selected soil over bark five to one while *C. grayi* was four to one bark over soil. The specificity of *C. chlorophaea* was less pronounced, occurring on soil twice as often as on bark. The percentage of each chemical species in the different stands (Fig. 3), showed variations as well. The pine habitat is particularly selective for *G. grayi* while having a low concentration of the other species. The birch and oak stands noticeably favor *C. chlorophaea,* while both *C. cryptochlorophaea* and *C. chlorophaea* were prevalent in the aspen habitat. All of the specimens determined to be the same chemically were examined under a dissecting microscope and found to exhibit no clearly discernible morphological characteristics which could distinguish them from the other species similarly studied. There seemed to be no empirical differences; however, at the conclusion of the study, I was able to predict quite accurately

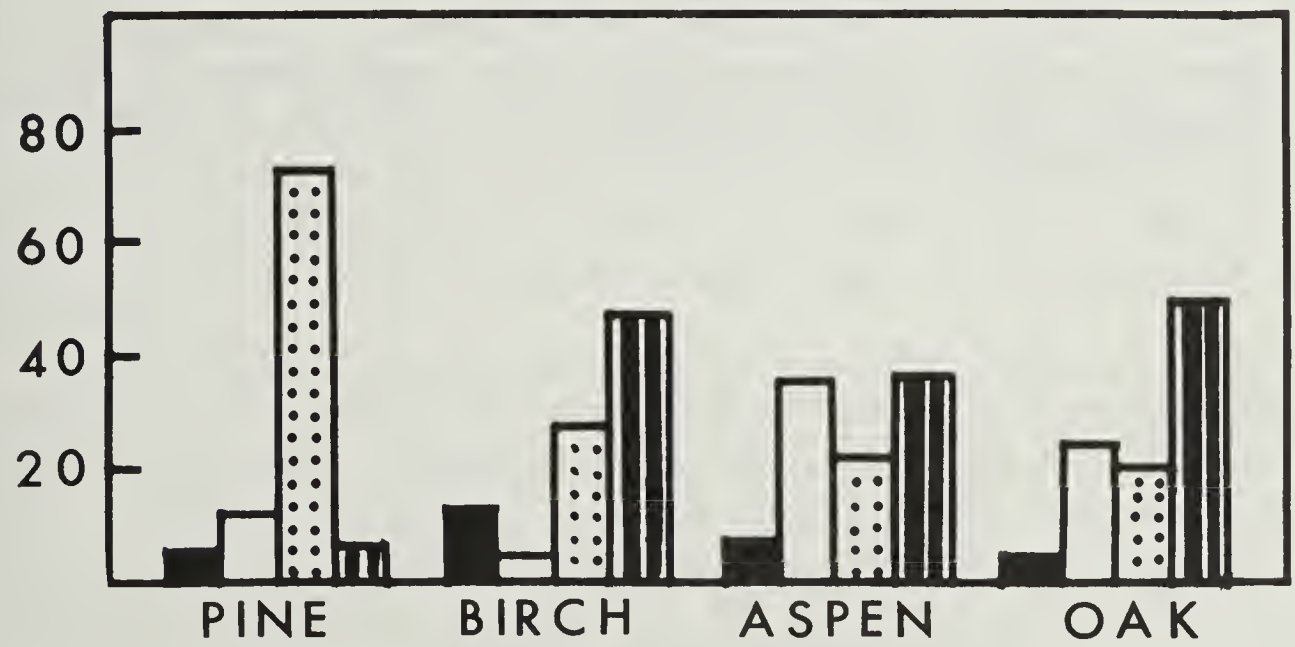

Fig. 3. Percent of each species within individual stands.

Solid black = merochlorophaea
White = cryptochlorophaea
Stipples = grayi
Bars = chlorophaea

which podetia belonged to which species. This can most likely be accounted for by a combination of characteristics which I suspect are more ecological than morphological.

Since this is the first study of its kind, my evaluation of these results can only be an educated guess. Mason E. Hale, who is familiar with this group, has told me that the overall percentages within the entire population are not out of the ordinary and would be expected to vary in different localities. However, the fact that individual communities may show percentages different from those of the population as a whole, strongly indicates an ecological preference of some kind. The results of the substrate specificity test also lend strong support to this possibility.

Whether the substrate or the microclimate is the major determining factor remains to be seen. What can be seen is that the various chemical species occur in different stands in different percentages, making up a percentage in the total population dissimilar to that of any individual stand. Two of the species, *C. cryptochlorophaea* and *C. grayi,* clearly show substrate preferences. Whether the various species result from their habitats or in spite of them is not for me to say.

ACKNOWLEDGMENTS

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STUDIES IN THE GENUS *CORTINARIUS*, I: SECTION DERMOCYBE, *CORTINARIUS AUREIFOLIUS* COMPLEX

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INTRODUCTION

Throughout the genus *Cortinarius* color has always been important in the classification of species. The colors of the pileus, stipe, lamellae, and context of the basidiocarp, as well as color changes in fresh material, are among the characters used. More recently the type and location of the pigment has been emphasized.

Taxa in the section *Dermocybe* are characterized by an innately fibrillose to squamulose, usually dry pileus, a dry stipe, and lamellae which are red, orange, yellow, greenish, olive, or brown when fresh. Some examples are *Cortinarius sanguineus* Fries, *C. chrysolitus* Kauff., *C. cinnamomeus* (Fries) S. F. Gray, and *C. raphanoides* Fries. The section is divided into smaller groups according to the color of the lamellae. This paper concerns some of the taxa which have greenish, olivaceous, or yellow lamellae, including *C. aureifolius* Pk.

Taxa in the section *Dermocybe* have tramal hyphae and/or basidia which often contain pigments occurring as granules or amorphous masses or as diffuse color in or between the cells. These pigments are observed in dry specimens sections of which are revived and mounted in 2.5% KOH. The following are a few of the taxa in which these pigments occur.

Cortinarius raphanoides has pale olivaceous-brownish lamellae when fresh. Hyphae of the lamellar trama contain a diffuse pale pinkish to pale reddish purple pigment and some red pigment-masses. The basidia contain red to reddish purple pigment and some red pigment-masses. The basidia contain red to reddish purple granules. In *C. chrysolitus* the lamellae are chrysolite green. The tramal hyphae contain red to reddish purple pigment-masses and the basidia contain a diffuse red to reddish purple pigment and similarly colored granules. In both of these species the color and nature of the pigment appear characteristic.

In *Cortinarius cinnamomeus* sensu lato the pigments are presently being studied. So far, we have observed two types of pigments. In some collections the pigment is yellow to yellow-orange in the tramal hyphae and basidia while in other collections the pigment is red to reddish purple. These different pigments occur in collections which appear to be otherwise similar, e.g., in habit, size, shape and roughness of spores, etc., but additional notes on fresh material are needed to clarify the features of the basidiocarps.

Two types of pigments similar in color to those in *C. cinnamomeus* sensu lato occur in the *C. aureifolius* complex. The following is a short introduction to the *C. aureifolius* complex, descriptions of the taxa, and a comparison of the important characteristics including the pigments.

Cortinarius aureifolius Complex

Cortinarius aureifolius was described by C. H. Peck in 1885 from material collected in Karner, New York. Since then it has only been collected occasionally and so far has not been reported from Michigan. Basidiocarps of this species are 4-5 cm high, grow in sandy soil under pines, and have colors of the stipe, lamellae, and pileus similar to those of *C. cinnamomeus.*

During the fall of 1967 and 1968 a *Cortinarius* resembling *C. aureifolius* was found at Fralick's Tree Farm, Hell, Livingston County, Michigan. Basidiocarps were growing under pines in sandy soil on bare or needle-covered areas and were often buried in the sand to the pileus margin. In October 1968 at least one hundred were collected on a small sandy slope.

The type collection of *C. aureifolius* was studied and compared with the Michigan material. Below are descriptions of the type collection of *C. aureifolius* and of the Michigan material.

Cortinarius aureifolius Pk.

Pileus 1.7-3.3 cm broad, convex, then plane or slightly depressed, densely fibrillose-tomentose, sometimes slightly squamulose, especially on the disk, cinnamon brown. Context yellow or pallid, odor like that of radishes.

Lamellae adnexed, yellow becoming yellow-cinnamon, rather broad, moderately close, subventricose, rounded behind.

Stipe fibrillose, yellow, short, solid, equal, brownish within; plants 2.5-3.8 cm high.

Spores (Fig. 1) 9.5-13.5(16) × 3.0-4.2μ, in side view obscurely elongate-inequilateral to subfusiform or fusiform-elliptic, in face view elliptic to oblong-elliptic, smooth or the surface finely irregular; in KOH, single spores dull light pale yellowish; in Melzer's solution, single spores yellowish, groups of spores light orange-yellow.

Basidia (23)27-40 × 5.5-7μ, broadly clavate, irregularly clavate, or elongate clavate, 4-spored, clamp connections present; in H_2O hyaline to yellowish or some containing yellow or reddish pigment; in KOH nearly hyaline or pale pinkish to pale purplish, some containing deep red to reddish purple granules; in Melzer's pale yellow to golden yellow, some with ± refractive contents and often containing yellow-orange, orange, or reddish orange granules. Basidioles 20-37 × 5.5-8μ, clamp connections present, similar in shape to basidia, in H_2O, KOH, and Melzer's similar in color to basidia. No pleurocystidia seen. Cheilocystidia scattered or in clusters, broadly clavate to vesiculose (difficult to revive); lamellar edge fertile. Lamellar trama sub-parallel-interwoven; sections in KOH pale reddish to pale pinkish purple or nearly hyaline, some hyphae containing masses of dark red to purple-red pigment; sections in H_2O yellowish, some hyphae containing masses of reddish to reddish orange pigment; sections in Melzer's yellowish to yellow-orange, some hyphae containing masses of reddish orange to red pigment. Hymenium in KOH ± colored similar to the lamellar trama; in H_2O yellowish; in Melzer's yellowish to yellowish orange; when sections of lamellar trama are mounted in KOH a reddish pigment diffuses into the mount.

Pileus cuticle of hyphae ± irregularly interwoven, up to 12-15μ broad, clamp connections present, hyphal end-cells rounded to clavate or tapered, occasionally broadly mucronate; sections in KOH pale "ochraceous tawny" to brownish orange, some individual hyphae nearly hyaline; in Melzer's yellowish, yellow-orange to dull orange ("ochraceous orange"). Pileus trama composed of interwoven hyphae; sections in KOH and Melzer's similar in color to lamellar trama, some hyphae containing masses of red to reddish purple pigment.

Hyphae on the surface of the stipe apex subparallel to interwoven, hyphal end-cells not differentiated (basidia and basidioles from the hymenium may occur at the immediate apex), clamp connections present; when sections are mounted in KOH a reddish pigment diffuses into the mount; hyphae in KOH nearly hyaline to pale pinkish or reddish (some surface hyphae yellowish), some hyphae containing dark red, ("scarlet red" or purplish red) pigment; hyphae in Melzer's "lemon yellow" to "lemon chrome" or orange-yellow, some hyphae containing golden yellow, orange, or reddish orange pigment. Surface hyphae from stipe base irregularly interwoven, hyphal end-cells not differentiated, clamp connections present, some hyphae with slightly yellowish thickened walls; in KOH and Melzer's similar in color to the surface hyphae at the apex but hyphae with reddish contents less common.

Growing in sandy soil under pines. October, 1885, Karner, New York. Collected by C. H. Peck.

R. Singer (F-1677) collected this species in Gainesville, Florida, December 30, 1942, in sandy soil under pines. His field notes agree closely with the description of *Cortinarius aureifolius.* The pileus was described as "snuff brown" to "Saccardo's Umber"; otherwise the coloration is similar to *C. aureifolius.* Our microscopic examinations revealed scattered to abundant vesiculose to broadly clavate cheilocystidia (13.5-25 X 8-12μ) which often form a sterile lamellar edge. Cheilocystidia of this nature were present in the type of *C. aureifolius* but did not form sterile lamellar edges as far as could be determined (hymenial elements of the type were often difficult to revive). The abundance of these sterile elements is apparently variable in this species.

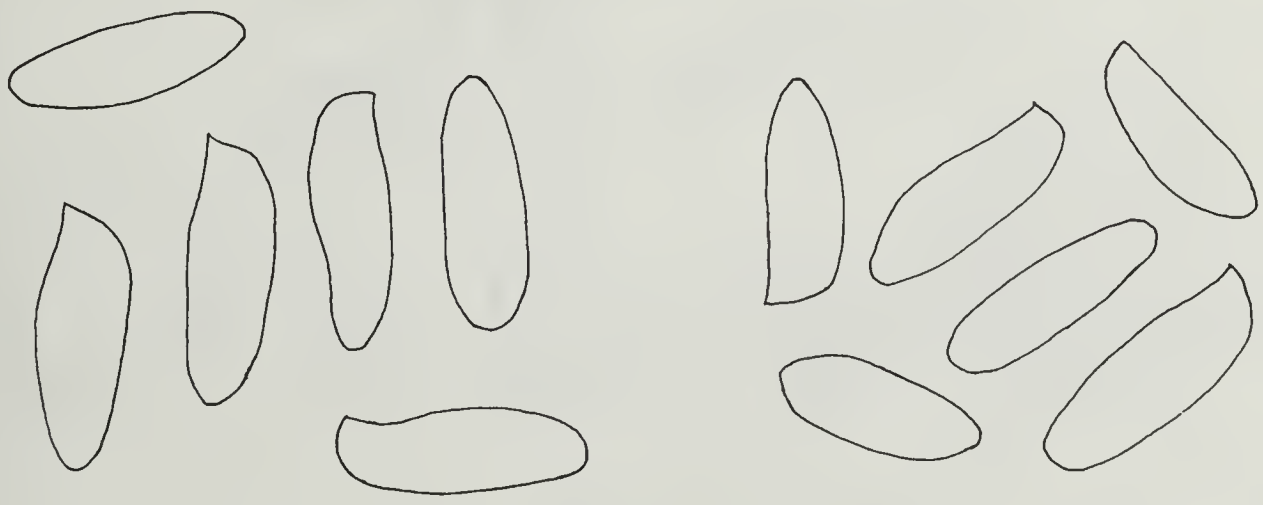

Fig. 1 (left). Spores of *Cortinarius aureifolius,* X1200.
Fig. 2 (right). Spores of *Cortinarius psammophilus,* X1200.

Cortinarius psammophilus sp. nov. (Figs. 3 & 4).

Pileus 1-3.5 cm latus, conicus vel convexus, demum plano-convexus, margine decurvus, fibrillosus demum squamulosus, brunneus, margine subolivaceus vel luteolus; caro albida demum sulphurea; lamellae stramineae vel luteae demum brunneae; stipes 1.5-4 cm longus, 3-7 mm crassus, stramineus vel luteus, deorsum brunnescens; cortina lutea; sporae 10-13 X 3-4.5μ, subfusiformis, laevis. Typus: *J. F. Ammirati, Jr. 2693* (MICH).

Pileus 1-3.5 cm broad, conic to convex becoming plano-convex, margin incurved to decurved but rarely plane, surface moist to dry, not hygrophanous, densely fibrillose to squamulose, "snuff brown," "buckthorn brown," or "sayal brown" with "Isabella color" or "light brownish olive" tints toward the margin, frequently tinted "wax yellow" on the outer margin, in some "bister" to "chestnut brown" on the disc, when rubbed discoloring "dark vinaceous drab" to "Mars brown," becoming ± purplish brown when wet. Context 2-3 mm thick on the disc, thinner over the lamellae, solid, firm to spongy, whitish to "pale yellow-green," "naphthalene yellow," or "sulphur yellow"; odor and taste of radish or slight to none.

Lamellae sinuate to uncinate or subdecurrent to decurrent, close, 2-7 mm broad, at first "straw yellow," "amber yellow," or "wax yellow" to "strontian yellow," then "yellow ocher" to "Isabella color," at length "snuff brown" to "buckthorn brown," some reddish spotted in age; when fresh reddish with the application of KOH.

Stipe 1.5-4 cm long, apex 3-7 mm thick, base 4-10 mm thick, clavate to slightly bulbous; surface appressed fibrillose or with ± scattered loose fibrils, "barium yellow," "straw yellow," or "amber yellow" to "wax yellow," lower stipe discoloring "snuff brown," "cinnamon," "natal brown," "bister," or rusty brown. Context "pale yellow green," "sulphur yellow," or colored as the stipe surface, especially in the cortex, becoming sordid in age, stuffed to hollow, cortex pliant. Cortina in young basidiocarps "barium yellow," "amber yellow" to "wax yellow."

Spore deposit on white paper deep rusty brown ("amber brown" or rusty "cinnamon-brown"); spores (Fig. 2) (9)10-13(15) X 3-4.5μ, shape sometimes ± irregular, in side view obscurely elongate-inequilateral to subfusiform or broadly subfusiform, in face view narrowly ovate, fusiform-elliptic or elliptic; in KOH near "ochraceous tawny" in groups, individual spores pale yellowish; in Melzer's dull yellowish orange in groups, individual spores light yellowish.

Basidia 25-30(35-37) X 6-8μ, 4-spored, clavate, narrowly clavate or irregularly clavate, clamp connections present; in KOH hyaline, greyish or light brownish, some containing yellow pigment as droplets or diffuse in the cell, occasionally containing reddish granules; in H_2O some containing bright yellow pigment; in Melzer's nearly hyaline to pale yellowish, greyish, or brownish. Basidioles 18-30(35) X (3-4)5-7μ, similar in shape to basidia, clamp connections present; in KOH, H_2O, and Melzer's similar in color to basidia. No pleurocystidia seen. Cheilocystidia absent or when present scattered or in clusters, broadly clavate to vesiculose or less commonly cylindrical; lamellar edges

fertile. Lamellar trama subparallel-interwoven; sections in KOH and H_2O hyaline to pale yellowish, some hyphae containing masses of bright yellow pigment; sections in Melzer's light yellow to pale yellow, some hyphae containing yellow pigment; hymenium in KOH and H_2O hyaline to yellowish, in Melzer's ± "ocher yellow"; when sections of lamellar trama are mounted in KOH a reddish brown to reddish or pinkish pigment diffuses into the mount.

Pileus cuticle hyphae ± radially to irregularly interwoven, up to 12-14μ broad, clamp connections present, hyphal end-cells rounded to clavate, less commonly tapered to broadly mucronate; when mounted in KOH a "tawny" to "vinaceous brown" or light reddish brown pigment diffuses into the mount, the hyphae finally light "tawny," "ochraceous tawny" to light brownish or some nearly hyaline; in Melzer's "tawny," "amber brown" to "hazel"; in KOH

Fig. 3. *Cortinarius psammophilus,* X1.

Fig. 4. *Cortinarius psammophilus,* X1.

some with yellowish thickened walls. Pileus trama composed of interwoven hyphae; sections in KOH hyaline to pale yellowish, some hyphae containing masses of pigment as in the lamellar trama; sections in Melzer's pale yellow.

Hyphae on the surface of the stipe apex subparallel to interwoven, hyphal end-cells not differentiated, clamp connections present, some hyphae encrusted; when sections are mounted in KOH a reddish to reddish orange pigment diffuses into the mount; in KOH the hyphae hyaline to yellowish or golden yellow to dull yellow-orange; in Melzer's pale yellow to pale rusty yellow. Surface hyphae from stipe base interwoven, hyphal end-cells not differentiated, clamp connections present, some hyphal walls encrusted; in KOH and Melzer's similar in color to surface hyphae at apex.

Gregarious to scattered or solitary under pines in sandy soil, basidiocarps often partially buried in the sand. October, Fralick's Tree Farm, Hell, Livingston Co., Michigan. *J. F. Ammirati, Jr. 1350, 1351, 1378, 1379, 2671, 2693* (type). Under pines, Waterloo Recreation Area, Washtenaw Co., Michigan, *F. Hoseney 1183.*

The elongate-subfusiform, ± smooth spores of *C. aureifolius* and *C. psammophilus* are very unusual in the genus *Cortinarius* and unite these taxa into a readily definable group. The spores are very similar in shape to those in the genus *Boletus.*

The color of the pileus in *C. aureifolius* is more uniformly brown than in *C. psammophilus* in which the margin is often tinted olivaceous and the outer margin is commonly yellowish when the basidiocarps are fresh. In other respects the colors of the basidiocarps when fresh are similar.

C. aureifolius and *C. psammophilus* differ in the color of the pigment in the tramal hyphae and basidia (mentioned in the introduction). When sections of the former are mounted in KOH the pigment masses in the hyphae of the pileus and lamellar tramae and the pigment and/or granules in the basidia are red to reddish purple. In *C. psammophilus* the pigment masses of the tramal hyphae and the pigment in the basidia are yellow and reddish granules are only occasionally seen in the basidia. Furthermore, in KOH the hyphae on the surface of the stipe of *C. aureifolius* contain red to reddish purple pigment while in *C. psammophilus* it is lacking.

The taxa in the *Cortinarius aureifolius* complex are clearly related by their spores, habit, and ecology. Differences in pileus color and the color and location of the pigment as described above form the basis for recognizing the taxa.

Pigment differences in other taxa of the section *Dermocybe* when correlated with other characteristics of the basidiocarps may prove important in defining the taxa, especially in the *Cortinarius cinnamomeus* group.

ACKNOWLEDGMENTS

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THE BOTANICAL ACTIVITIES OF THOMAS J. HALE, 1858-1862[1]

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Thomas J. Hale is best known for his two papers entitled "Additions to the Flora of Wisconsin" which appeared in the 1858 and 1860 volumes of the Transactions of the Wisconsin State Agricultural Society (Hale 1858, 1860a). The 1858 paper was a joint effort with Increase A. Lapham, who did the mosses, liverworts, and lichens. Very little is known concerning Hale's other botanical activities. This paper comments on the activities of this important plant collector.

Hale lists Racine, Wisconsin, as his address on many of his earlier labels but I have found no information on where he was born or where he lived. According to University of Wisconsin records he entered the classical course of the university in 1857 at the age of 23. He was active in the Hesperian Society, a debating and literary society, and served as president from 1859 to 1860. Hale was apparently an excellent student with grades ranging from 94 to 96. He received his bachelor's degree in 1860 and his master of arts degree three years later.

About the time Hale received his B.A. the state geological and agricultural survey was formed. Hale began work in the survey as a field assistant under the direction of Dr. Ezra Carr, professor of botany at The University of Wisconsin, Madison. During the years 1860-1862 he worked for the survey as a field assistant under Prof. James Hall, a geologist. His assignment was to collect fossils throughout the state and to map certain sandstones, at the same time collecting plants. During this period (1860-1862) he spent some of his winters in Albany, New York, where Hall was working on a geological survey of that state.

Hale's letters provide an interesting comment on the activities of a field botanist a century ago. His request for funds for the summer of 1860 was $1.50 per day and $170.00 with which he outfitted himself with a horse, wagon, and harness (Hale, 1860c). On July 15, 1860, he was in Whitewater when he wrote Prof. Hall regarding his problem in finding lodging because so many farmers mistook him for a peddler. "I have tried to stay at farm houses several times but they all seem to think that I want to pay them in pins" (Hale, 1860d). In several letters to Hall, Hale seems to dwell on his several aches and pains which periodically plagued him (Hale, 1860e, 1860f). Once while suffering from the ague he commenced the use of gentian, perhaps the ague weed, *Gentianella quinquefolia* (Hale, 1860b).

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[1]Presented at the Botanical Club of Wisconsin section of the 99th meeting of the Wisconsin Academy of Sciences, Arts, and Letters at Whitewater, May 3, 1969.

One of Hale's greatest problems as a field botanist was the preparation of good specimens. He frequently excused his poor specimens when writing other botanists. He wrote Daniel Cady Eaton stating that "I have so little time to spare from my geology that I necessarily do my work in haste" (Hale, 1860j). Later he wrote that he must acknowledge his inability to make fine specimens while journeying with night air only to dry his papers (Hale, 1861c). These poor specimens irked at least one of his botanical correspondents, the eminent Kentucky botanist, Dr. Charles Wilkins Short, who wrote Increase Lapham saying that Mr. Hale had sent him some interesting collections from Wisconsin but that Hale did not take the pains which Lapham did to "make his specimens fine" (Short, 1862).

Hale established correspondence with most of the leading botanists of his day. In 1859 he wrote Lapham asking for the addresses of botanists in various parts of the country as he has "no botanical acquaintance" (Hale, 1859). Two years later he wrote D. C. Eaton asking for the addresses of additional botanists although he was already corresponding or exchanging specimens with an illustrious list of botanists including Asa Gray, Samuel Barnum Mead, [C. J.?] Sprague, George Vasey, Elias Durand, M. S. Bebb, [T. C.?] Porter, George Engelmann, Moses A. Curtis, [J. W.?] Chickering, Stephen Thayer Olney, Reuben Nevius, Wm. M. Canby and "many lesser lights" (Hale, 1861d).

To distribute specimens to so many correspondents required the collection of large numbers of plants. By the end of the collecting seasons Hale had several hundred species, apparently with duplicates, to trade. In 1860 he collected enough *Asclepias lanuginosa*, now rare in southern Wisconsin, to "satisfy every American botanist" (Hale, 1860c). (This species was described in his 1858 paper as a new species, *Acerates monocephala* Lapham "unless it should be united with *A[cerates] lanuginosa* Decaisne"). He mentions collecting such "rare" plants as *Agoseris cuspidata, Castilleja sessiliflora,* and some grasses in quantity for trade (Hale, 1860g). He offered George Engelmann "several rare species in quantity" (Hale, 1860h). Hale also collected many mosses but felt constrained to give up their study in order to concentrate on rocks and herbaceous plants. He asked for the address of the moss expert William Starling Sullivant in order to offer him his collection (Hale, 1860j). He engaged the services of a "young man at Madison" to collect plants common in that area for trade (Hale, 1861a). This may be a reference to Samuel H. Watson, then a student at the University of Wisconsin (Musselman, 1969).

Although best known for his plant collections in Wisconsin, Hale also collected a few specimens in Minnesota, Iowa, and Illinois. Some representative labels of T. J. Hale are shown in Fig. 1. The localities in which he collected are mapped in Fig. 2. From his letters it is also evident that Hale did geological work in many areas from which I have seen no plant specimens.

Hale's collections are of interest because many plants he collected have not or rarely been seen in these areas since he collected them. For example, he sent a *Senecio* to Gray in 1861 which Gray determined to be *Senecio palustris (S. congestus),* a northern species which Hale had collected in south-

ern Wisconsin at Madison (Hale, 1860i). Hale's specimen is not in the Herbarium of The University of Wisconsin, Madison, but the specimen he sent to Gray may still be in the Gray Herbarium. In 1860 he collected *Ruellia humilis* (wild petunia) at Beloit where it has only been collected once since.[2] Apparently many of Hale's specimens survive in herbaria which contain the collections of Hale's correspondents. If Hale kept a collection of his own, I have not been able to locate it.

Hale found plants which he assumed to be new species and sent them to Gray, Engelmann, and Eaton to be named. He took particular interest in the genus *Euphorbia* as he was trying to "work out the genus in the state" (Hale, 1861c). Hale also took an interest in the carices, mosses, and the gerardias. In 1861 he sent Gray a parcel of plants which Hale assumed to have several unnamed species. He left Gray to describe the new species "trusting that you will do me such honors as I have deserved, if any of the plants should prove

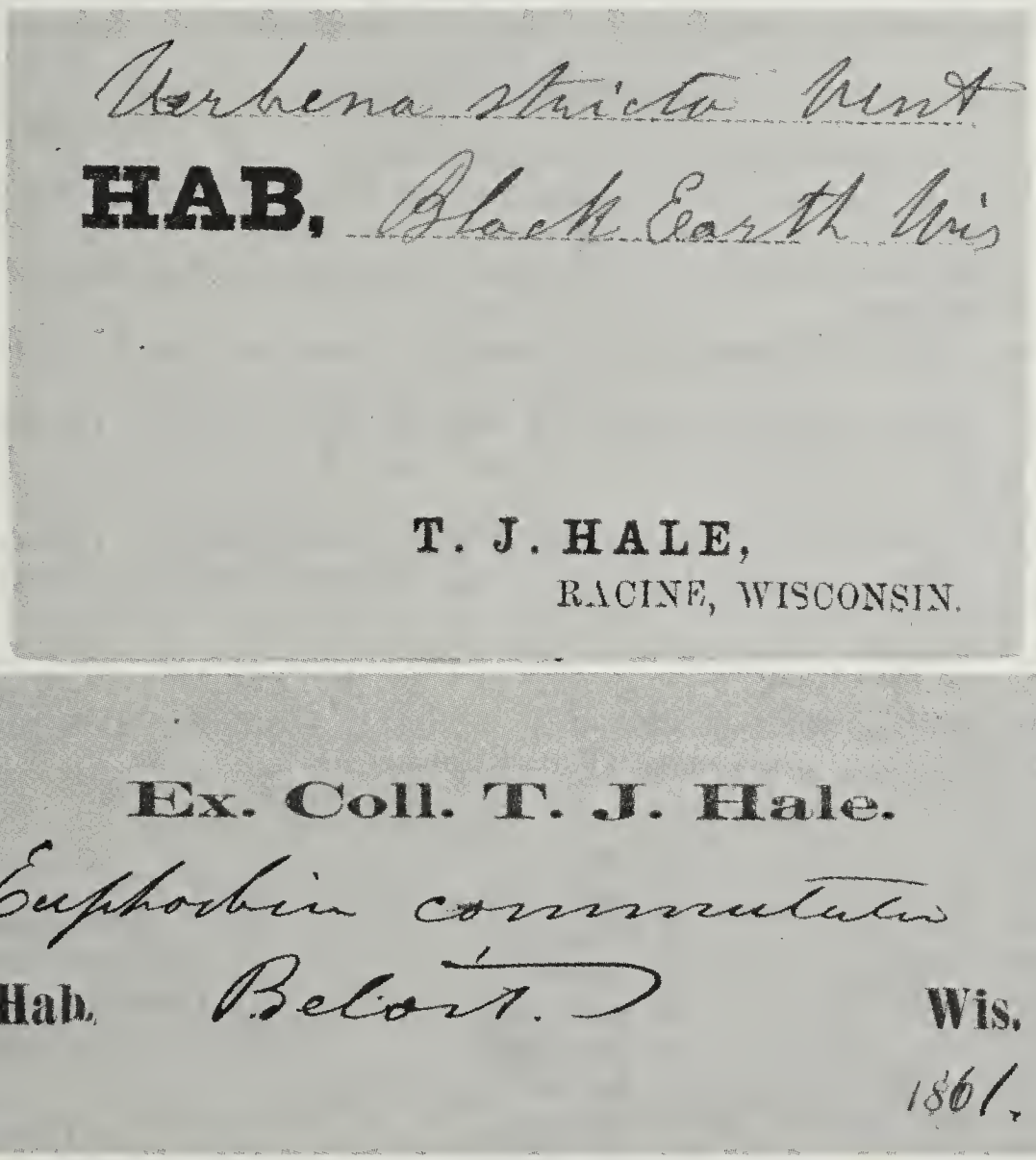

Fig. 1. Representative labels of T. J. Hale: an original label apparently from Hale's own collection and an exchange label.

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[2]"*Ruellia ciliosa* Pursh, Beloit, Aug. 30, 1894, G. B. Olds." In the Beloit College Herbarium.

to be not described" (Hale, 1861b). Included with this group of plants was a *Gerardia* which Gray later named *Gerardia tenuifolia* var. *asperula* (Gray, 1879).

Hale's botanical career ended abruptly in 1862 when the legislature abolished the state geological and agricultural survey. Hale had fallen out with James Hall and left Milwaukee hastily while teaching a summer course (Hale, 1862). He apparently died before 1879 because Gray, when describing the *Gerardia* which Hale had sent, refers to him as the "late Mr. Hale" (Gray, 1879).

ACKNOWLEDGMENTS

Portions of this work completed during the summer of 1968 were incidental to research supported by a University of Wisconsin Center System Summer Research grant. This work would not have been possible without the generous assistance of many librarians and curators who kindly searched manuscript collections for letters of Hale. Special credit is due J. E. Boell, director of the archives of the University of Wisconsin, for obtaining information of Hale's university activities and also to Margaret Gleason of the State Historical Society of Wisconsin for checking several federal census reports.

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————. 1860c. Letter to D. C. Eaton, June 4. Yale University Library, New Haven, Conn.

————. 1860d. Letter to James Hall, July 15. New York State Library, Albany.

————. 1860e. Letter to James Hall, Aug. 10. New York State Library, Albany.

Fig. 2. Map showing collection sites of T. J. Hale in Wisconsin, Minnesota, Iowa, and Illinois, compiled from labels in the Milton College Herbarium (MCW). Numbers correspond to localities as listed below:

Wisconsin

1. St. Croix Falls
2. St. Croix County
3. St. Croix River
4. Lake Pepin
5. Black River Falls
6. Sturgeon Bay
7. Green Bay
8. De Pere
9. Kaukana
10. La Crosse
11. Lamartine
12. Kilbourn City
13. Sauk City
14. Hartford
15. Arena
16. Black Earth
17. Madison
18. Lake Mills
19. Waukesha
20. Milwaukee
21. Racine
22. Kenosha
23. Burlington
24. Beloit
25. Fulton
26. Blue Mounds
27. Dodgeville
28. Benton
29. Platte Mounds

Minnesota

30. St. Paul-Minneapolis Area
31. Dakota County
32. Cannon River
33. Fillmore County

Iowa

34. Dubuque

Illinois

35. Freeport

———. 1860f. Letter to James Hall, Oct. 27. New York State Library, Albany.
———. 1860g. Letter to ?, Nov. 28. Yale University Library, New Haven, Conn. (In the D. C. Eaton papers.)
———. 1860h. Letter to George Engelmann, Dec. 3. Missouri Botanical Garden Library, St. Louis.
———. 1860i. Letter to D. C. Eaton, Dec. 13. Yale University Library, New Haven, Conn.
———. 1860j. Letter to D. C. Eaton, Dec. 17. Yale University Library, New Haven, Conn.
———. 1861a. Letter to D. C. Eaton, Jan. 5. Yale University Library, New Haven, Conn.
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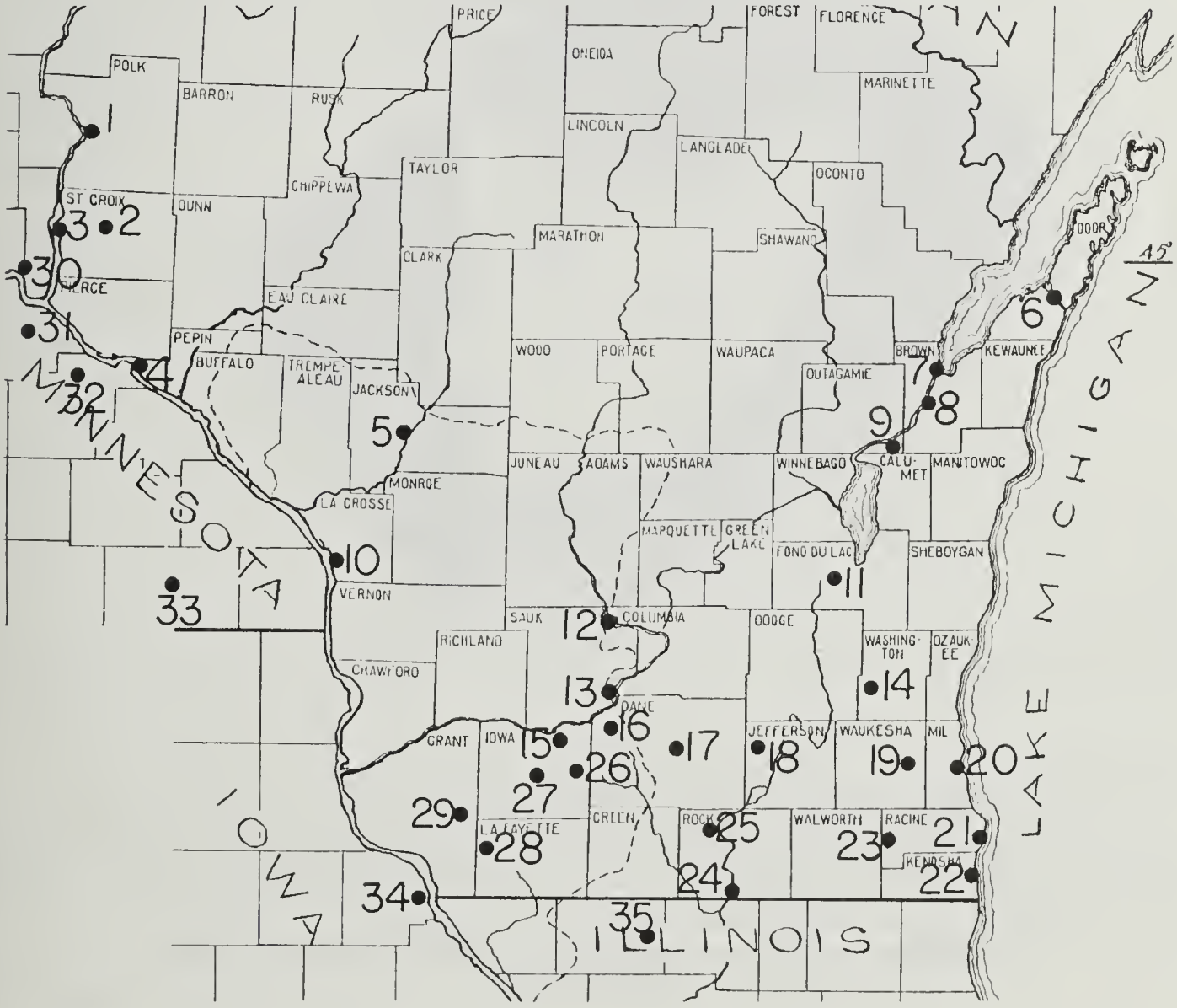

Bessie Bernice Kanouse (November 21, 1889–January 28, 1969)
(About 1930)

DR. BESSIE BERNICE KANOUSE–1889-1969

Alexander H. Smith
Herbarium, The University of Michigan, Ann Arbor

Bessie Bernice Kanouse was born at Quincy, in Branch County, Michigan, November 21, 1889. She attended the secondary schools of Quincy, and later taught in the public schools of the state from 1908 to 1912. In 1915 she received the bachelor's degree from Eastern Michigan University, which at that time was known as the State Normal College at Ypsilanti, Michigan. From 1915 to 1917 she taught nature study in the public schools of Gary, Indiana, and from 1917 to 1921 was supervisor of general science for 33 public schools at Camden, New Jersey. In 1921 she enrolled at the University of Michigan, where she received her A.B. in 1922, her M.S. in 1923 and her Ph.D. in 1926. She was appointed as Curator in the University Herbarium in 1926, and assistant to the Director in 1928, positions she held until her retirement in 1960. She continued to reside in Ann Arbor for a number of years following her retirement, and then moved to Coldwater, Michigan, where she passed away January 28, 1969.

Because of her long association with natural history as a hobby, then as a teacher, and finally as the one responsible for the care of one of the country's important research collections of fungi, it is not at all surprising that she was one of the founders of the Michigan Wildflower Association–which eventually became the Michigan Botanical Club. At the organizational meeting May 31, 1941, she was elected as the first secretary-treasurer of the Wildflower Association.

Dr. Kanouse's scientific work was centered in the fungi, where she did important research both on watermolds and on Discomycetes, on which subject she was a frequent contributor to the Papers of the Michigan Academy of Science, Arts, and Letters. She belonged to the Michigan Academy; Mycological Society of America; Michigan Parks Association; Michigan Natural Areas Council; Women's Research Club of the University of Michigan; Washtenaw Historical Society, of which she was a life member; the Midwest Museums Society, of which she was a charter member and later an honorary member; the National Society of the Women of New England and a member of the Ann Arbor Colony; Sigma Xi; American Association for the Advancement of Science (fellow); and the National Society of the Daughters of the American Revolution. She also served on the board for the Wesley Foundation, and was a patroness for Phi Beta Phi.

Dr. Kanouse was deeply interested in philosophy and American literature, and when no longer able to engage in the strenuous field work of collecting fungi turned to reading, and also tried her hand at writing. She was an artist at heart, as well as a scientist. At the University she will be remembered for her efforts to build up the fungous collections, and although she did not teach classes, will be remembered by many graduate students for the help and advice she gave them.

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A SEEDLING POPULATION OF ASPENS IN SOUTHEASTERN MICHIGAN

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The North American aspens, *Populus tremuloides* Michaux (trembling aspen) and *P. grandidentata* Michaux (bigtooth aspen) typically occur in clones, aggregations of genetically identical stems (ramets), produced asexually by root suckering (Barnes, 1966). Disturbances such as fire, logging, and grazing favor the development of sucker stands (Baker, 1925; Fetherolf, 1917; Sampson, 1919; Weigle and Frothingham, 1911).

Most of the aspens in existence today were probably derived asexually and did not arise directly from seedlings as is typical of most forest trees. Graham et al. (1963) conducted extensive studies in aspen stands in the Lower Peninsula of Michigan and failed to find a single seedling stand of merchantable size. A similar predominance of sucker stands was found in northern Minnesota (Kittredge & Gevorkiantz, 1929).

Although a clone must originate from a seedling (the ortet), establishment of seedlings is very difficult and seedling stands are rare (Barnes, 1966). Seedlings are rare because a favorable combination of biotic and environmental conditions is necessary for establishment. However, during investigations of hybrids between the two species of aspen in southeastern Michigan (Barnes, 1961) many putative seedling hybrids were observed. They were numerous along the edges of abandoned fields particularly where the field was adjacent to a woodlot. The discovery of such a natural population growing in an abandoned portion of a cultivated field provided the opportunity to study the structure, origin, and development of a stand markedly different from most present-day aspen stands in Lower Michigan.

The objectives of the study were to determine (1) the number of seedlings, i.e., different genotypes, in the population, (2) the origin of the population, and (3) the incidence of hybridization.

THE RESEARCH AREA AND METHODS

The population under study, about 0.17 acre in size, is located along the west and south edges of an abandoned portion of a cultivated field adjacent to Stinchfield Woods, a forest property of The University of Michigan (Fig. 1). The elevation is approximately 990 feet. The soil type is a Boyer sandy loam. Second-growth stands of oak and hickory, predominantly *Quercus velutina* Lam., *Q. rubra* L., *Q. alba* L., *Carya ovata* Mill., and *C. ovalis* Wang., surround the population to the west, north, and south. Clones of bigtooth aspen were found in the stands north and east of the population.

The history of the establishment of the population was determined with the help of the original General Land Office Surveys, various settlement histories of Washtenaw County, aerial photographs, and personal communication

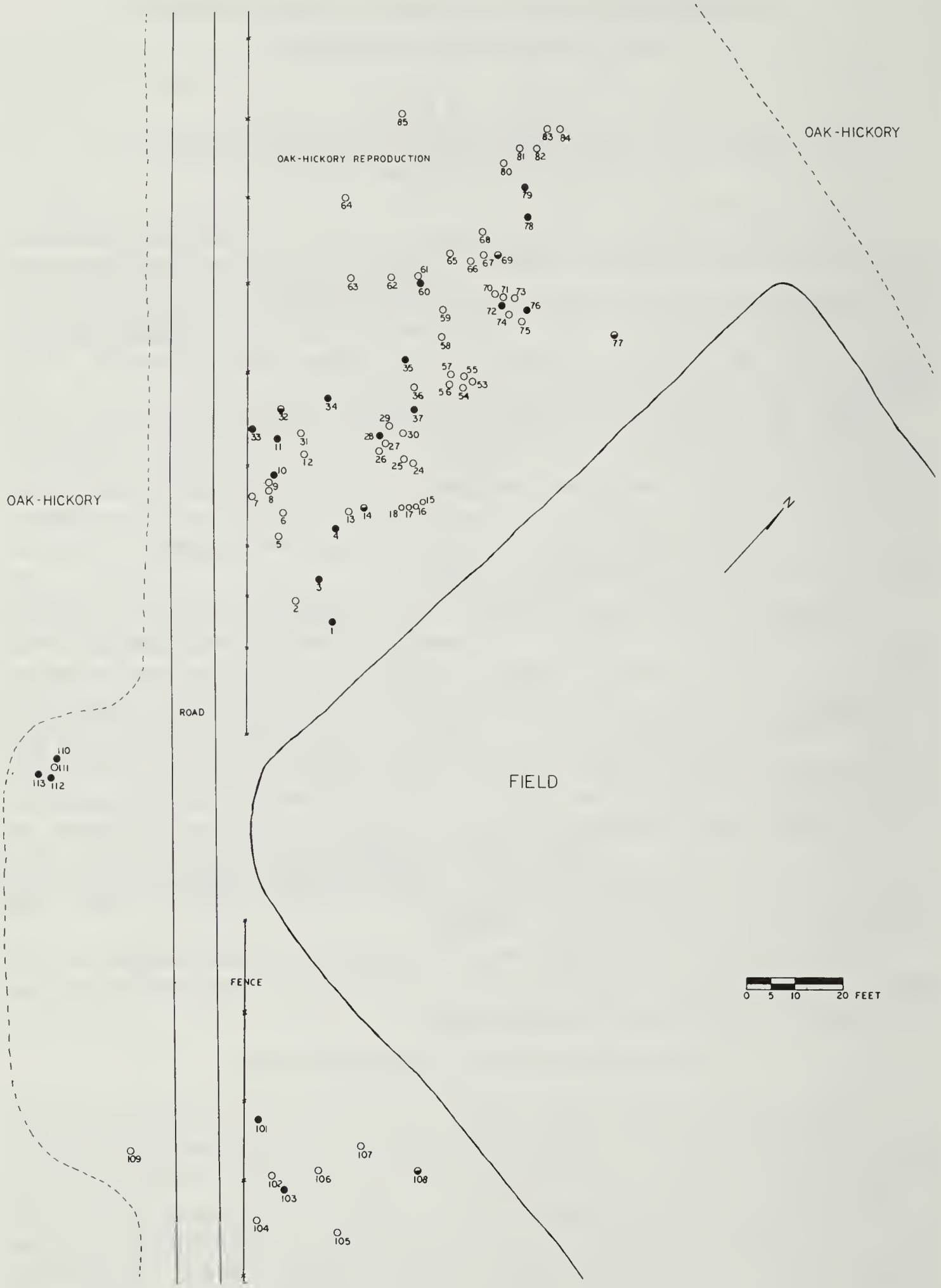

Fig. 1. Map of the research area showing the location of *P. tremuloides* (●), *P. grandidentata* (O), and hybrid individuals (◒). The road forms the northeastern border of lot 59 of Stinchfield Woods, forest property of the University of Michigan, Washtenaw Co., Michigan.

with Mr. Frank Murray, former manager of the forest properties of the University of Michigan.

All aspen stems 2 inches in diameter at breast height (dbh) and larger were numbered and mapped. The dbh of each stem was measured with a diameter tape and the height was measured with an Abney level. Increment borings of several of the larger individuals were taken to determine their age.

Vertification of the seedling origin of each stem would have necessitated observing seed fall, germination, and subsequent development of the plant. Seedlings might also be identified by root excavations since the root system of a seedling is distinguishable from that of a sucker, at least initially. Although we were unable to use these methods, we adopted a method which approximates the number of seedlings by determining the number of different genotypes (clones) in a given stand. Of the total number of stems, the greater the number of different clones represented, the greater the number of seedlings established. For example, if a population of 100 stems were all similar in morphology and phenology, we would consider them as 100 ramets of 1 clone or possibly 1 seedling ortet and 99 ramets. If 80 of the 100 stems were different in their characters, i.e., represented different genotypes, a predominantly seedling stand would exist. Obviously, various combinations of seedlings and multi-stemmed clones may exist in a given stand due to establishment conditions and subsequent disturbance. This method tends to underestimate the number of seedlings, particularly if there are many stems involved. Two or more genotypes may have some similar characters and time is usually not sufficient to study all possible differentiating characters.

Following the guidelines formulated by Barnes (1969), the characters used to distinguish different clones were as follows:

1. Taxon: *P. grandidentata, P. tremuloides,* or *P. grandidentata* × *P. tremuloides.*
2. Sex: ♂, ♀, or ⚥.
3. Leaf morphology: Overall shape and size, blade base shape, blade tip shape, petiole length, number of teeth per side of blade.
4. Phenology: time and stage of flowering, time and stage of leaf flushing, time of leaf drop, autumnal leaf color.

From all numbered stems, 4 to 6 shoots bearing "early" leaves were collected in June, 1967, after the foliage had expanded fully. The shoots, 1.5 to 3 in. long, were taken from inside lateral branches in the middle and lower portions of the crown. Five undamaged leaves from the middle portion of the shoots of each tree verified to be a different genotype were selected for measurement. Two leaves at most were taken from any 1 shoot. The following measurements were made on each leaf:

1. Total blade length, cm.
2. Maximum blade width, cm.
3. Petiole length, cm.

4. Number of teeth per leaf side.
5. Total length of shoot from which the leaf was taken, cm.
6. Distance from the bud scar at base of shoot to the point of leaf attachment, cm.

Leaves of selected individuals were mounted and photographed.

In March, 1967, before buds began to swell, 10 to 20 terminal buds were taken from each tree. These were then examined for amount of pubescence on the bud scales. Stage of flowering was observed on 3 different dates in 1967 and periodically in 1968.

Before pollen discharge began, branches of male individuals bearing flower buds were taken to the greenhouse of The University of Michigan Botanical Gardens and placed in containers of water. Pollen was collected 4 to 8 days later. The pollen was stored in a refrigerator and later examined to determine percentage of abortion and diameter of grains. The pollen of each tree was mounted on a glass slide and stained with aceto-carmine. At each of 10 random positions on the slide, the diameters of 10 grains were measured. At each position all grains in the field of view were counted and the percentage of aborted grains, those collapsed and lacking cytoplasm, was computed. The average number of grains observed per clone was 275.

After pollination had taken place in the spring of 1967, a branch from each female individual bearing fruit was taken to the greenhouse, and placed in a container of water. The seeds were subsequently collected. After about 2 weeks' storage in a refrigerator, seeds of each female tree, with 4 exceptions, were counted into 3, 50-seed lots and placed on moist filter paper in petri dishes. Germination was observed daily and, at the end of 5 days, total germination was recorded.

To facilitate comparison of the 2 aspen species with their putative hybrids, a hybrid index was devised using 6 leaf and bud characters. Coefficients of variation were computed to compare the variability of leaf traits and pollen diameter of the taxa.

RESULTS AND DISCUSSION

HISTORY OF ESTABLISHMENT

At the time of settlement by white men, Washtenaw County was primarily covered by a hardwood forest. General Land Survey notes of 1819 indicate that the area where the research site is now situated was "very hilly oak land." In pre-settlement forests, aspens were probably uncommon and inconspicuous trees, as they apparently were in other parts of the Lake States (Barnes, 1966). However, on sites disturbed by fire or Indian cultivation, they probably were more frequent in occurrence. The Land Survey notes show that aspens were occasionally used as witness trees in swamps and along the edges of lakes, rivers, and streams. The surveyors used "aspen" in their notes and distinguished it from cottonwood or "poplar." Aspens made up 2.2% of the total number of species mentioned in Washtenaw County. The closest aspen

cited was located approximately 1 mile east of the research area, where the section line crossed the Huron River.

The land on which the stand is located was probably cleared some time before 1880. The area that is now Stinchfield Woods was grazed by sheep until about 1935, when the University of Michigan began purchasing the second growth oak-hickory stands. In 1953, the University purchased a corner of the field, 0.57 acres, and during the summer of that year constructed a road giving better access to hardwood stands east and north of the field. Aerial photographs taken in 1940 and information provided by Mr. Frank Murray indicate that, prior to the time of road construction, no aspens existed where the population grows today; that area was then part of the cultivated field.

Evidence from increment borings and aerial photographs indicates that aspens probably became established during the 1953 or 1954 growing season. Seeds probably came from female clones growing along the perimeter of the field to the north. When the road was constructed across the corner of the field, the end of the field was narrowed so that it became difficult to maneuver equipment for plowing. Thus, in 1954, a strip of ground at the end of the field was not planted although it may have been plowed. The abandonment of this portion of the field and the process of road building provided exposed mineral soil, a highly desirable seedbed for aspen seedlings. The weather records of 1954 show that June was above average in temperature and was the second wettest June in Michigan on record up to that time (U. S. Dep. Commerce, 1954). Therefore, the seedbed and moisture conditions were very favorable for the establishment of aspen seedlings.

THE SEEDLING STAND

Of the 78 stems numbered and mapped, 54 (or 69% of the total) were conclusively verified as different genotypes: 35 of *P. grandidentata,* 14 of *P. tremuloides,* and 5 of putative F_1 hybrids. The remaining 24 stems could not be positively distinguished from the other clones. However, none of these individuals could be definitely identified as a ramet of one of the 54 clones. It is probable that more study would reveal that many of these also represent different clones and thus would increase the percentage of sexually produced individuals.

Generally, each of the 54 stems constituted what might be called "single-tree clones," presumably the ortet only—a seedling plant. Along the edges of the field adjacent to the population, suckers from one or two of the ortets have begun to appear where cultivation has severed or injured roots. Apparently, only in this area are the typical multi-stemmed clones currently being initiated. The finding of no signs of other disturbance and that the small stand is even-aged, support the conclusion that the remaining 24 stems also may be seedlings.

Reports of seedling aspens are infrequent. In the Great Basin region of Utah, Baker (1925) suggested that conditions for seedling establishment last occurred in the late Pleistocene. Similarly, Cottam (1954) stated that *P. tremuloides* ceased reproduction by seed in Utah at the onset of the Post-

pluvial climate, approximately 8,000 years ago. In the eastern United States, a preponderance of sucker stands has been noted (Graham et al., 1963; Kittridge & Gevorkiantz, 1929). Although it is obvious that seedlings must have been established before multi-stemmed clones could originate, reports of recent seedling establishment are also rare. Larson (1944) reported several hundred established seedlings along the shoreline of a receded reservoir in Utah. Barnes (1966) discovered numerous aspen seedlings on recently burned sites in northern Idaho. Thus, seedlings can become established in certain areas of the West where both climatic and soil conditions are suitable.

In the East, Faust (1936) discovered seedlings established along a receded reservoir; and many regeneration surveys after fire have indicated that aspen "seedlings" were among the invading species (Ahlgren, 1959; Gauvin, 1964; MacArthur, 1964; Mills, 1961; Vogl, 1969). In Michigan, Graham et al. (1963) reported several seedling populations that arose after fire or logging, and in one instance in the seedbeds of a forest nursery.

Evidence of seedling establishment in northern Lower Michigan was indirectly provided by Bertenshaw (1965) who found that on a given acre the number of clones ranged from 26 (average of 15 ramets per clone) to 174 (average of 5 ramets per clone). Because of periodic fires in the area, it is unlikely that any of the trees on these acres are the original seedlings. However, the evidence does indicate that many seedlings were established sometime in the recent past.

It is not surprising that seedling aspens are uncommon. First, seedling establishment is difficult and only occurs through the favorable combination of many environmental and biotic factors. Second, aspens sucker profusely following disturbance, and a seedling stand may be transformed quickly into a sucker stand. Suckers may arise as soon as the second year on the root system of a seedling (Day, 1944). Sucker-promoting disturbances such as fire, logging, and grazing are very common throughout the ranges of the aspens.

Although establishment of seedlings is difficult, they are probably much more frequent than published reports indicate. Reports of seedlings are infrequent because of the above reasons and also because it is very difficult to establish that a given stem is a seedling unless the tree is young. Root connections decay and suckers establish independent root systems (Barnes, 1966; DeByle, 1964). For these reasons determining the proportions of different genotypes to the total number of stems in a population is a more feasible method to resolve the number of seedlings established than root excavations. However, it cannot pinpoint the date of origin of the clones without additional information of seedfall, seedbed, and other environmental conditions.

CHARACTERISTICS OF THE POPULATION

Height, Diameter, and Growth

Considerable variation among the 54 verified seedlings was found in the growth attributes of each taxon (Table I). The hybrids slightly exceeded the parent species in dbh, total height, and annual growth. Although the differ-

Table I. Mean dbh, height, and growth rate for *P. tremuloides, P. grandidentata,* and their hybrid in the population studied. Age approximately 13 years.

Taxon	No. of Individuals	DBH		Total Height		Mean Annual Growth	
		Mean	Range	Mean	Range	Diameter	Height
		–in–		–ft–		in	ft
P. tremuloides	14	3.5	2.0-4.7	29.5	24.0-37.0	0.24	2.4
P. grandidentata	35	4.5	2.2 -6.4	34.3	17.0-42.0	0.32	2.6
Hybrid	5	4.6	3.7-5.5	35.3	30.0-41.5	0.33	2.7

ences were negligible and only a few hybrids were present, it was apparent that on this site hybrids could become established and compete successfully with both parents to an age of approximately 13 years.

Sex and Hermaphroditism

The ratio of males to females for trembling aspen was 7:5; 2 additional clones were hermaphrodites. The corresponding ratio for bigtooth aspen was 17:14. Four clones did not flower. Three of the 5 hybrids were female and 2 were hermaphroditic. Of the latter 1 was predominantly female and 1 was predominantly male. Although aspens are reported to be dioecious, it is well known that many clones are bisexual (Erlanson & Hermann, 1928; Lester, 1961; Pauley & Mennel, 1957; Santamour, 1956). Einspahr (1960) reported that the incidence of the bisexual condition in wild populations of trembling aspen may range from 4% to 20%. Following the terminology of Westergaard (1958), both parents and the hybrid should be considered "subdioecious," i.e., some bisexual plants occur regularly in nature besides exclusively male and female plants.

Leaf Flushing

The average date of leaf flushing (bursting of buds and expansion of leaves in the spring) of trembling aspen was approximately 8 days earlier than that of bigtooth aspen. In northern Lower Michigan, Barnes (1969) found the difference between the 2 species to range from 2 to 4 weeks depending on site conditions. Differences in the initiation and progress of flushing for different stems of trembling aspen were conspicuous. In 1967, the earliest trembling aspen clone began flushing on April 16 and the latest on May 6, a difference of approximately 3 weeks. In northern Lower Michigan a similar observation was made for trembling aspen (Barnes, 1969). Although bigtooth aspens were more uniform in the initiation of flushing, notable differences appeared as flushing progressed. The flushing of hybrid individuals most nearly resembled trembling aspen in initiation and sequence.

Leaf and Bud Characteristics

As expected, marked variations in leaf shape, size, margin, base, and tip were observed in both species and the hybrids. The leaf margin is a very good trait by which the parents may be differentiated and hybrids distinguished from the parents (Fig. 2). Terminal buds of trembling aspen were glabrous except for minute hairs on the basal scales of some individuals. Bigtooth aspen was characterized by dense pubescence on the central portion of each scale; pubescence was sparse along the margins of the scales. The hybrids lacked the extremely dense pubescence of bigtooth aspen, but had instead only relatively dense pubescence on the lower scales and numerous scattered hairs on the upper scales.

Flowering

Trembling aspen began shedding pollen before bigtooth aspen. The mean first flowering date separating trembling and bigtooth aspen in Ontario is approximately 8 days (Bassett et al., 1961). No comparable data are available from this study. Although trembling aspen flowered first, at least 4 days before the earliest bigtooth aspen, considerable overlap was observed. For example, receptive female flowers of trembling aspen, as judged by fully extended and brilliant red stigmas, were present as late as April 8, 1967, well into the anthesis period of bigtooth aspen (March 26 to April 16).

HYBRIDIZATION

To determine the relationship of the putative hybrids to the parent species, 5 leaf characters (blade width, blade length, ratio of blade width to blade length, petiole length, number of teeth per leaf side) and the pubescence rating of terminal buds were selected and the mean, standard deviation, and coefficient of variation determined (Table II). The mean values of the hybrids were approximately mid-way between the means of the parents except for blade width and petiole length, in which they were closer to trembling aspen. There was considerable overlap between the hybrids and trembling aspen in

Table II. Variation of 5 leaf characters of *P. tremuloides, P. grandidentata,* and their hybrid in the population studied. Means (m), standard deviation (s), and coefficient of variation (cv).

Taxon	Blade									Petiole Length			No. of Teeth Per Leaf Side		
	Width			Length			Width/Length								
	m	s	cv	m	s	cv	m	s	cv	m	s	cv	m	s	cv
	–cm–		%	–cm–		%			%	–cm–		%			%
P. tremuloides	6.3	0.88	14.0	6.0	0.72	11.9	1.0	0.09	8.6	4.8	1.14	23.8	31.4	4.52	14.4
Hybrid	6.7	0.86	12.8	8.0	0.45	5.6	0.8	0.08	9.5	5.4	0.60	11.2	20.2	2.07	10.2
P. grandidentata	8.5	0.72	8.5	9.3	0.72	7.8	0.9	0.07	7.6	6.9	0.94	13.6	9.9	1.30	13.1

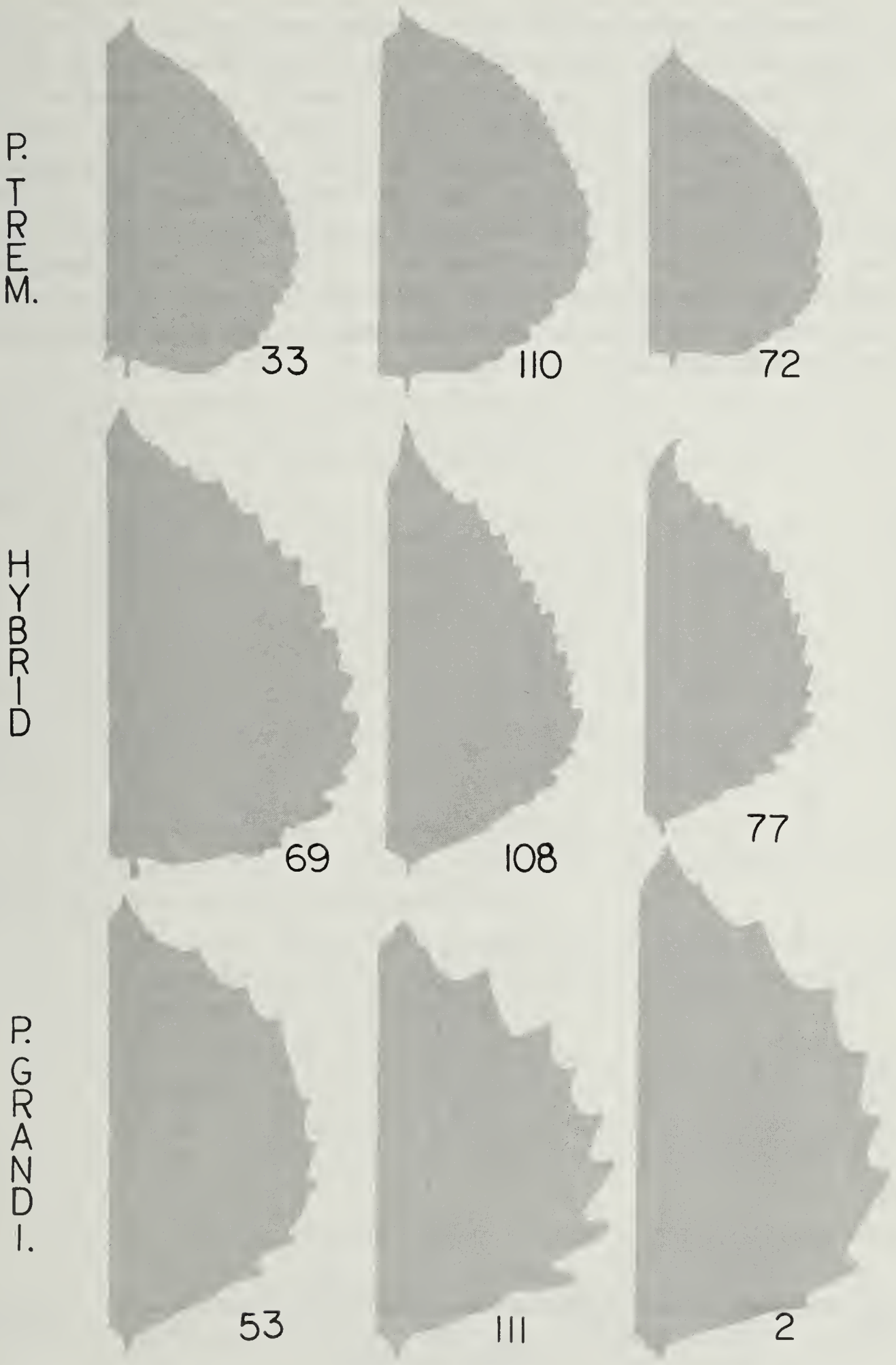

Fig. 2. Silhouettes showing leaf size and margin differences of representative individuals of *P. tremuloides, P. grandidentata,* and their hybrid in the population studied. Scale: X0.6.

these characters (Andrejak, 1968). Similar findings were reported by Barnes (1961). Trembling aspen was the most variable species in all characters. Bigtooth aspen was the next most variable with the exception of blade width.

Two hybrid indices were computed to examine the relationship of the hybrids to the parents; one utilized 5 leaf characters and the pubescence rating; the other used the 3 best distinguishing characters between the parents: blade length, number of teeth per leaf side, and pubescence (Fig. 3). Both indices showed the hybrids approximately mid-way between the parents. From this and observation of other leaf traits, we conclude the intermediate plants are F_1 hybrids. Although the hybrids were similar to trembling aspen in petiole length and blade width, we believe it is unlikely that these individuals are backcrosses or introgressants.

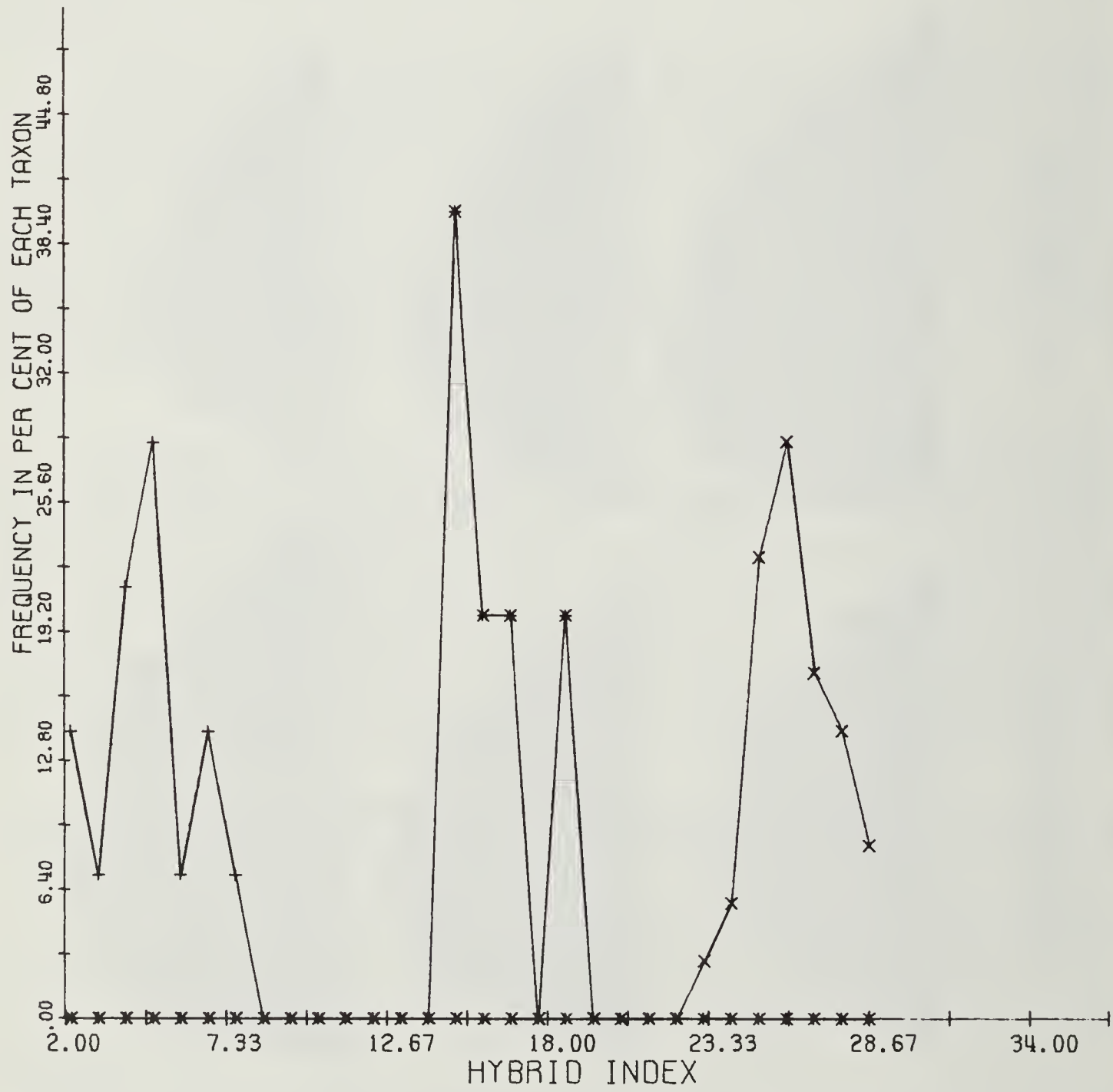

Fig. 3. Graph of frequency distribution of hybrid index using 3 characters. *P. tremuloides* (+) 14 plants, *P. grandidentata* (x) 35 plants, and hybrid (*), 5 plants. (Graph was prepared by a CalComp Plotter from a Fortran IVG program in the Michigan Terminal System.)

Hybrids between the species may be produced by controlled pollination with ease (Heimburger, 1936; Pauley, 1963). Natural hybrids have been reported from Massachusetts (Pauley, 1956), Quebec, Canada (Victorin, 1930), and the Lake States (Barnes, 1961; Einspahr, 1960). Barnes (1961) found numerous hybrids in southeastern Michigan in contrast to their rarity in northern Lower Michigan. He estimated they might represent from 1 to 5% of the clones in the areas studied. The reasons postulated for the occurrence of hybrids were an overlap in flowering time, and favorable climatic and seedbed conditions.

Although *P. tremuloides* usually flowers in advance of *P. grandidentata,* this isolating mechanism is not complete. Barnes (1961) and Einspahr and Joranson (1960) reported that intraclonal variation in both species may sometimes be great enough to cause the flowering times to overlap substantially. Also, Pauley (1956) suggested that temperature inversions in some areas may retard the flowering of female *P. tremuloides* to coincide with the pollen discharge of *P. grandidentata.*

Observations of the Stinchfield Woods population show that considerable overlap in flowering exists. In 1967, there was a 14-day period when *P. tremuloides* flowers (late flowering females) were receptive and *P. grandidentata* males (early flowering clones) were discharging pollen. On April 8, 1967, *P. tremuloides* stem #60 was observed to have receptive female flowers on some catkins at a time when *P. grandidentata* clones were shedding pollen. Similarly on April 5, 1968, *P. grandidentata* #12 was at the peak of pollen discharge while *P. tremuloides* #35, 25 ft away, had many receptive female flowers.

Excluding temperature inversions and other environmental factors, overlap in flowering of female trembling aspen and pollen shedding of male bigtooth aspen may occur in the following ways:

1. All of the flowers of inherently late-flowering female trembling aspen clones may be receptive and receive pollen from early flowering clones of bigtooth aspen.
2. Some female flowers on the distal portion of some catkins of trembling aspen are apparently receptive after flowers on the rest of the catkin have been pollinated. We have observed such flowers to be receptive during the normal pollen shedding period of bigtooth aspen.
3. Late-flowering whole catkins of certain clones produce receptive flowers after most of the catkins on the same ramet are pollinated. Einspahr and Joranson (1960) observed this pehnomenon on 5 female clones and 1 male clone of trembling aspen in the greenhouse and on 1 female trembling aspen in nature. We also observed this feature in the greenhouse and in nature and found that flower buds at the base and tip of the shoot are most likely to produce late-flowering catkins.

Although trembling aspen seems more likely to be the female parent of hybrids, male trembling aspens also may have the opportunity to pollinate bigtooth aspens. For example, in 1967 and 1968, *P. tremuloides* #1 was observed shedding pollen when *P. grandidentata* #2, 10 ft away, had receptive female flowers. On April 1, 1968, during the anthesis of *P. tremuloides,* a branch from *P. grandidentata* #18, containing receptive female flowers, was removed and taken indoors, eliminating the possibility of further pollination. This was accomplished 4 days before any *P. grandidentata* males were observed to begin shedding pollen. Pollen grains were observed on the stigmas.

In summary, flowering time is clearly not a complete isolating mechanism in southeastern Michigan. If the population described here is any indication, many hybrid seeds must be formed. Although the cross *P. tremuloides* ♀ × *P. grandidentata* ♂ is most likely, the reciprocal is also possible. The 5 hybrids, 9% of the verified clones and 6% of all individuals, were undoubtedly established as a result of the cultivation and the favorable soil moisture conditions. Because of the relative incompleteness of the flowering time barrier in southeastern Michigan where the parent species occur together, lack of adequate seedbed conditions may be a more important factor in restricting the occurrence of hybrids than time of flowering.

Pollen

The mean pollen abortion values for trembling and bigtooth aspen, 2.1% and 4.9% respectively, were relatively low, and in this study were not significantly different ($P > .05$). Clonal differences in pollen diameter, coefficient of variation for pollen diameter, and abortion percentage were not great for the 5 trembling aspens from which pollen was available. However, the pollen of bigtooth clones showed marked variations in diameter and abortion rate. Abortion percentage varied from 0.4% to 12.2%. Six of the 16 clones had abortion percentages above 5%. Within-clone variation in pollen grain diameter was significantly correlated ($P < .01$) with abortion percentage ($r = 0.77$). The one male hybrid had a comparatively high abortion percentage, 18.7%, and showed more variability in size of pollen grains than either parent (standard deviation about twice that of either parent).

Seed Germination

Seed germination was excellent for the 1 trembling aspen, 93%, and the 13 bigtooth aspens, mean = 95%. The 2 hybrids tested on filter paper both had a germination of 89%. Seeds from 4 clones, 2 bigtooth and 2 hybrids, were tested only on a sand substrate. The percentages for the former were 96% and 43%, and for the latter, 87% and 4%. The low germination of the 1 hybrid may have been due to self-pollination of this hermaphroditic individual and the possibility that most of the seeds used in the test were not sound seeds. Maini (1964) found that bisexual flowers of *P. tremuloides* had a large percentage of aborted seeds. We conclude that the germination of open pollinated seeds from hybrids is only very slightly reduced from that of the parents. This agrees with the experience of the junior author who has repeatedly

found high seed set and germination from open pollinated flowers of hybrids. Heimburger (1936) reported that artificially produced hybrids between these species "yielded good seed."

Although several individuals suspected of being backcrosses or introgressants were reported by Barnes (1961), there is as yet no compelling evidence of these phenomena in Michigan aspens. However, this study has shown that hybrids do have a high germination capacity and can compete with the parent species well into flowering and fruiting age. Given suitable seedbed conditions, backcrosses may be established in areas where hybrids coexist with the parent species.

SUMMARY

A population of 78 aspens, *Populus tremuloides, P. grandidentata,* and their hybrid, growing along the edge of a cultivated field adjoining the University of Michigan's Stinchfield Woods, Washtenaw Co., Michigan, was investigated to determine the number of seedling individuals, to account for their establishment, and to determine the incidence of natural hybridization. The stand was established about 1954. Fifty-four of the stems were verified as different genotypes through studies of phenology and leaf morphology. They were presumed to be seedlings. Due to the even-aged character of the stand and lack of disturbance the remaining individuals probably are also seedling plants.

Considerable overlap was observed in the flowering of trembling and bigtooth aspen. There was approximately a 2-week period when late flowers of trembling aspen individuals were receptive to pollen from bigtooth aspens. Less frequently, female flowers of bigtooth aspen were receptive when pollen from trembling aspen was being discharged. Five individuals were determined to be F_1 hybrids between trembling and bigtooth aspen. Seeds from 3 of the 4 female hybrids were highly germinable. Except for the relative scarcity of hybrids there seems to be no stronger barrier to the production and establishment of successive backcross generations than there is for the production and establishment of seedlings of the parent species.

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Editorial Notes

INDEX: Notice to Librarians, Subscribers, Binders. No index appears in this final number of Vol. 8. A three-year index, covering Volumes 7, 8, & 9, is planned at the end of Vol. 9, following the pattern established in Vol. 3 and Vol. 6. Thus far, three volumes have made a unit of practical size for binding. In the future, if we are able to continue an increased size of volumes, an annual index may be prepared. Expressions of opinion from readers would be welcome, regarding a useful frequency of indexing.

The May number (Vol. 8, No. 3) was mailed May 16, 1969.

Errata

Vol. 8, No. 1 (Jan. 1969, p. 16. Scale of map should read: 1 cm = approx. 63 m.

Vol. 8, No. 2 (March 1969), p. 74. Right half of scale should be headed cm.
p. 92. Date of Fig. 14 should read May 29, 1966.
p. 96. Right column of Table III, line 17, for "has been" read had been.
p. 97. line 15 from bottom, for "as will be" read and as will be.

Vol. 8, No. 3 (May 1969), p. 164 (rear cover). Add name of author after fourth line from end of Contents: Florence V. Hoseney.

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(On the cover: Jordan River below Chestonia Bridge, Antrim County, Michigan. Photo by John P. Schnell, July 26, 1969; reprinted by permission from newsletter of the Mackinac Chapter, Sierra Club.)

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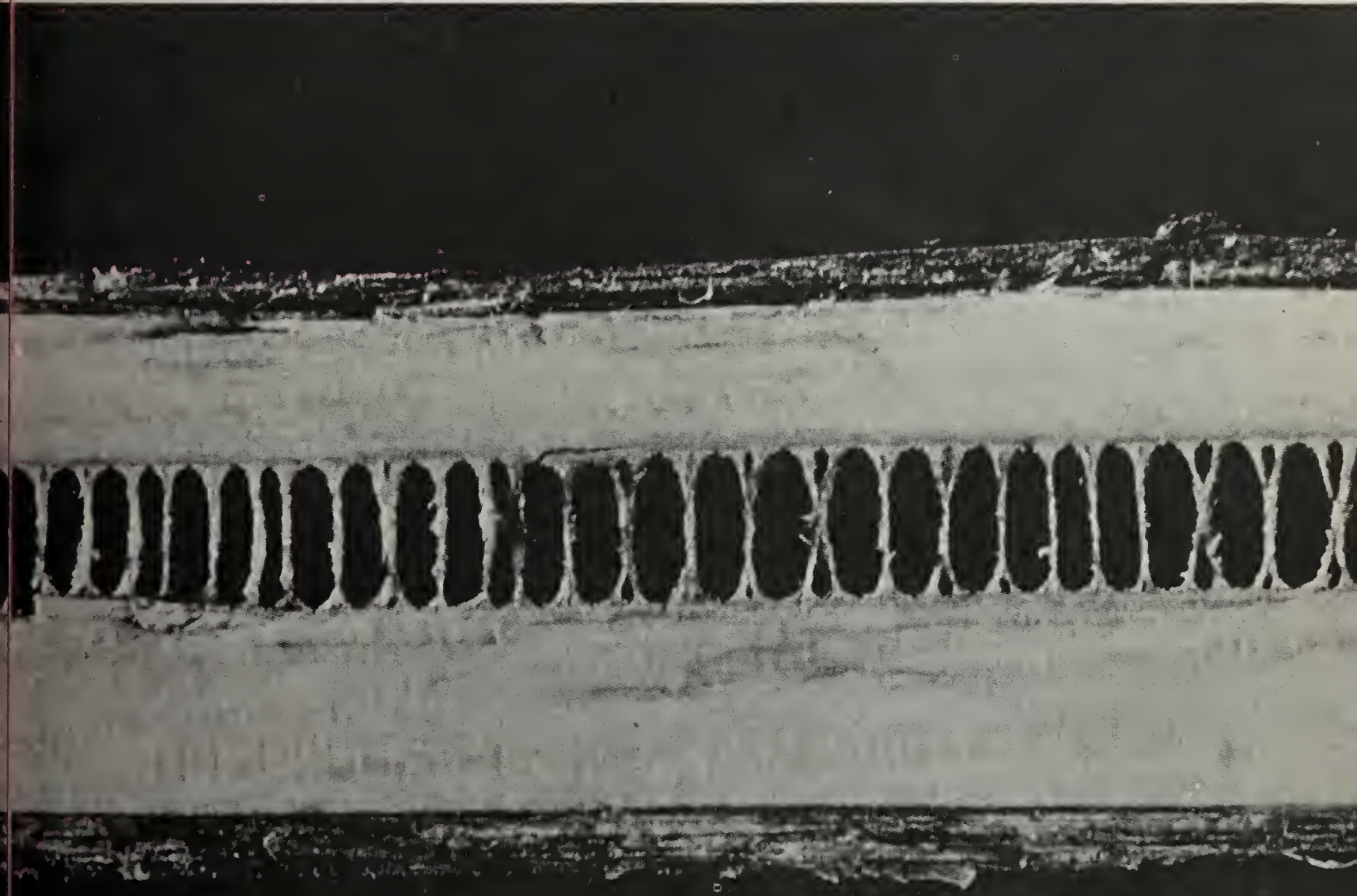

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POST-SETTLEMENT INFLUENCES UPON A SOUTHERN MICHIGAN MARL LAKE[1]

Peter H. Rich
W. K. Kellogg Biological Station, Michigan State University,
Hickory Corners, Michigan

The origins of several excavations in the marl basin of Lawrence Lake were investigated during an intensive limnological investigation of the lake. Interviews with local residents revealed a long history of marl removal and much additional information concerning post-settlement land and water usage in the area. Patterns in the cultural history of Lawrence Lake are discernible, and may be common to other marl lakes in southern Michigan.

Lawrence Lake, also known as Willison's and East Lake, is 2.1 km (1.3 mi) east of the village of Hickory Corners in southern Barry County (Fig. 1). Hickory Corners enjoyed prosperity in the 19th century out of proportion to its present size (population ± 220). In 1880, prior to the establishment of a railroad on the west side of Gull Lake, Hickory Corners was an important trading center for the area, and had a population of 150 people. Hickory Corners Road, immediately north of Lawrence Lake, was built in 1837. The road has since been regraded but has not been significantly relocated in the Lawrence Lake area.

Lawrence Lake, Little Lawrence Lake, and the marsh associated with them are contained in a basin lying along the southern outwash apron of the Kalamazoo morainic system (Leverett & Taylor, 1915). The soil surrounding the basin is generally a sandy loam of moderate fertility with good to rapid drainage (Deeter & Trull, 1928; Veatch, 1953). The marsh bordering Lawrence Lake is extensively underlain by marl. Casual observation suggests that peat is a major component of the marsh south of the lake.

Lawrence Lake has an area of 4.9 ha (12.1 a) and a maximum depth of 12.6 m (41.3 ft). It receives two small streams from a drainage basin roughly 10 times the surface area of the lake (Fig. 1). Lawrence Lake drains into a small unnamed lake, then south through an extensive marsh to Augusta Creek. The lake has a distinct marl bench at its border, unless removed by dredging. Dredged areas are discernible on the morphometric map (Fig. 2) by the departure from simple concentric contour lines on the north side, the west end, and a small area in the southeast corner of the lake. The bench occurs from waters-edge to a depth of 1 m and may extend up to 20 m from shore. Excavations have shown that the marl underlies a much broader zone around the lake. For instance, marl occurs, and is reputed to be 11 m deep, at the extreme western end of the lake which is now 50 m back from the original shoreline. Recent cores by Dr. R. O. Kapp of Alma College indicate that marl is at least 5 m thick beneath the deepest point in the lake.

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[1]Contribution No. 181, W. K. Kellogg Biological Station of Michigan State University.

AGRICULTURE

The first house in the Hickory Corners area was built near a flowing spring just west of Little Lawrence Lake in 1834. Watercress (*Nasturtium officinale*) was immediately introduced into this and nearby springs. Peppermint (*Mentha piperita*) was added about 1890. Both species are present today. Two bogs containing native cranberries (*Vaccinium macrocarpon* and *V. oxycoccos*) surrounded springs near Little Lawrence Lake and were exploited. Furthermore, the land surrounding many springs was actually plowed and cultivated for various garden crops. "Swamp shoes" on the hooves of horses prevented miring in the treacherous ground. The shoes were hardwood planks, about 2 decimeters wide and 3 dm long, with an iron harness for attachment. Despite the danger of miring and snakebite, cattle and sheep were also allowed on the marshes to graze. Although Deeter and Trull (1928) state that prairie sites and well drained "oak openings" were preferred agricultural land in the county, my information suggests that marshes also received significant attention.

The earliest lumbering in this region may well have been concentrated on wet areas. The original tamarack (*Larix laricina*) was tall and straight

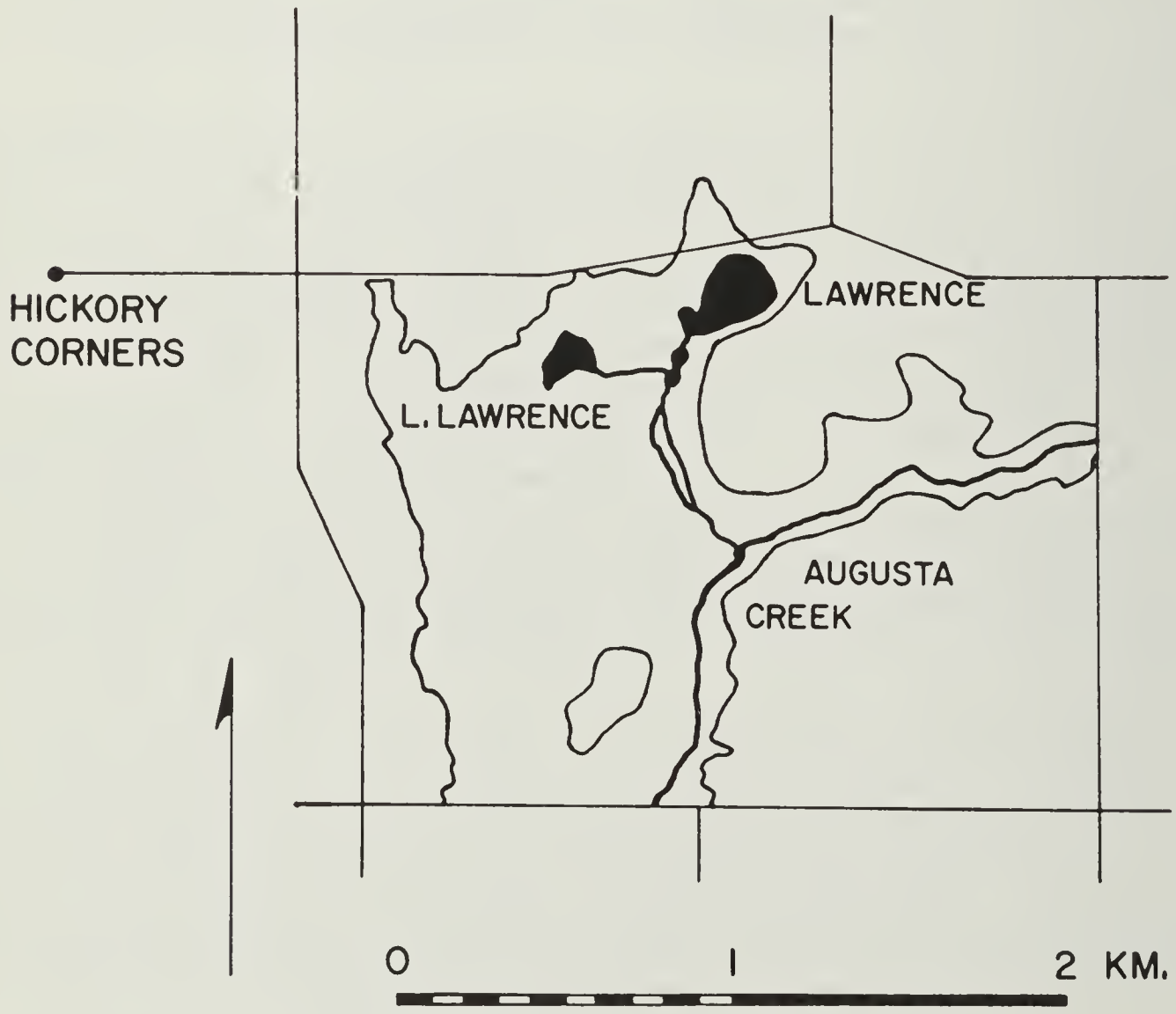

Fig. 1. Map of Lawrence Lake and vicinity, Barry County, Michigan, delineating marshy area.

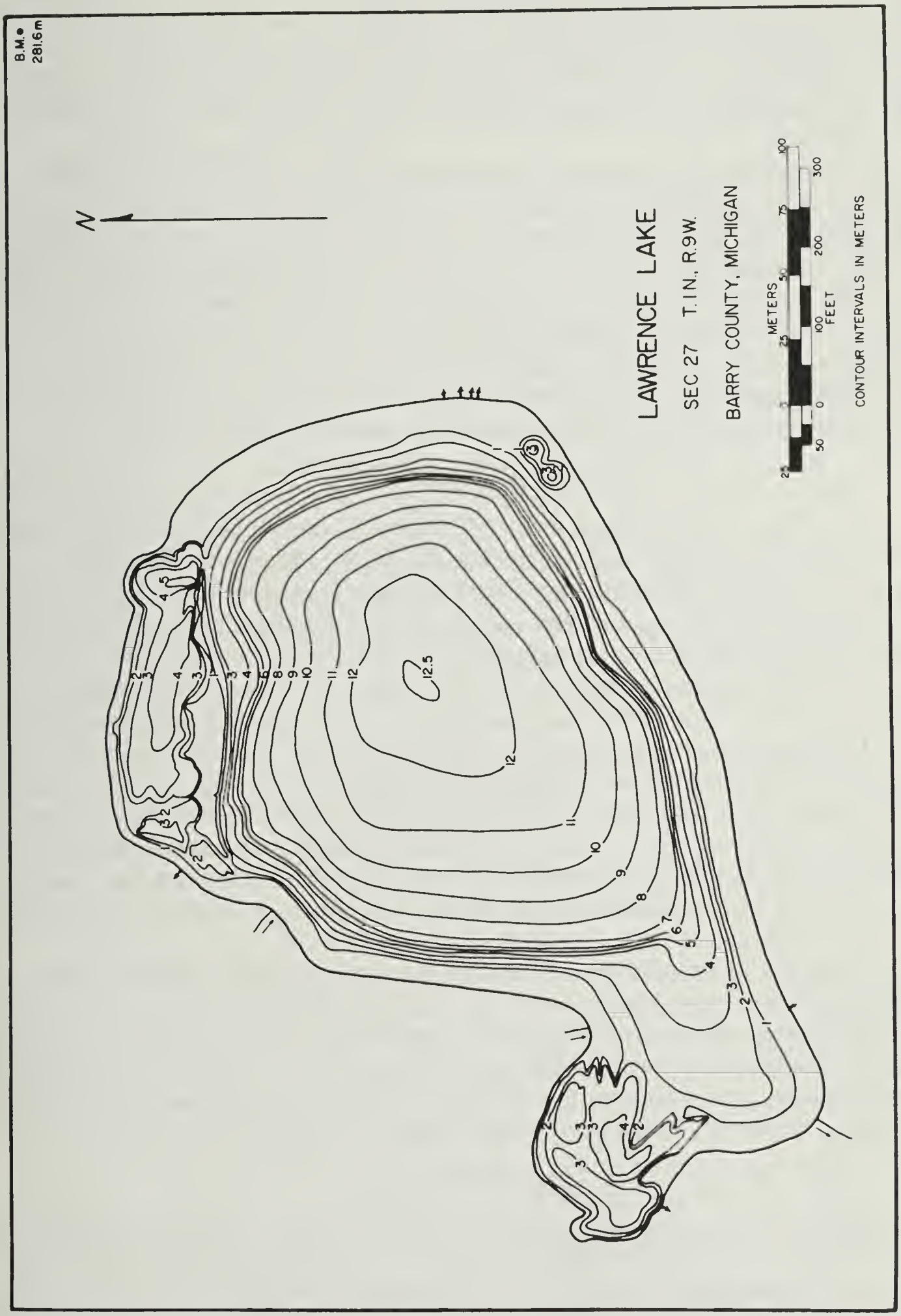

Fig. 2. Morphometric map of Lawrence Lake, Barry County, Michigan. Surveyed and contoured by high-frequency sonar in 1967.

enough to be preferred for rafters in houses and barns, with the result that no large tamarack have existed near Lawrence Lake in the memory of those now living in the area. White cedar (*Thuja occidentalis*) was also removed early. A narrow border of hardwoods along the southern shore of Lawrence Lake is largely virgin, but has suffered from soil compaction by cattle, selective cutting, and Dutch elm disease. All other trees around the lake are recent second growth.

In the early 20th century, from about 1918 to 1930, the marsh west of Lawrence Lake was ditched, irrigated, and intensively cultivated for commercial crops of onions, celery, mint, etc. A smaller area of marsh northeast of the lake was planted to rye for one season, 1891, and has remained fallow since. Today, both areas are dominated by shrubby cinquefoil (*Potentilla fruticosa*). The presence of blazing-star (*Liatris spicata*) in the older, less disturbed area suggests that the original community may have been a wet prairie. Since 1930, agricultural use of land near Lawrence Lake has declined to occasional pasturing and watering of stock at the extreme eastern corner.

LAND RECLAMATION

Attempts to drain large areas of the marsh near Lawrence Lake began about 1870 and were related to the expansion of agricultural enterprise. The very large number of deaths attributed to the "summer fever" in the Lawrence family records suggests that mosquito control must have motivated later reclamation efforts. Natural drainage from the west side of the marsh south of Lawrence Lake was first diverted to Little Lawrence Lake. This modification is known to have made Little Lawrence appear muddier than it had previously.

Lawrence Lake and the small, unnamed lake to the south were allowed to continue draining to Augusta Creek through the east side of the marsh. Later, water from Little Lawrence Lake was channeled east to the unnamed lake. The unnamed lake, originally having a barren marl shelf, was almost divided in two by the spoil from the ditching operation. The lake now has the appearance of two connected ponds almost overgrown by aquatic plants (Fig. 1).

Attempts to straighten and deepen the drainage from Lawrence Lake to Augusta Creek were hindered by an abandoned beaver dam encountered 50-100 m south of the unnamed lake. Dynamite was used at the site in 1930 to open the channel further. The dynamiting, which coincided with several drought years, was followed by reduced water levels in Lawrence Lake for two years. Beaver still exist on the upper parts of Augusta Creek.

MARL REMOVAL

Marl has been removed from the Lawrence Lake area since settlement. From 1840 to the middle 1890's a lime kiln operated just west of Lawrence Lake. A narrow-gauge tramway ran south from the kiln to Little Lawrence Lake where the marl was mined. A dirt road now covers the tramway bed. Quicklime produced from the kiln was used for plaster in nearby homes. The demand for firewood required by the kiln may have accelerated tree cutting

nearby, but no marl was removed from Lawrence Lake itself during this period.

Marl was first removed from the western end of Lawrence Lake about 1918. Demand may have resulted from the introduction of alfalfa, which was thought to require calcium, into the agriculture of the period. Marl was removed during the summer, and transportation was accomplished by horse-drawn sledges during the winter.

Shortly after the publication of the county soil survey (Deeter & Trull, 1928), which recommended liming in both light and heavy soils, increased demand and the introduction of mechanized draglines brought about large-scale marl removal at Lawrence Lake. The western end of the lake was dredged from 1930 to about 1960, and spoil banks of marl are still in evidence. Marl removal at this site since 1918 has produced a bay roughly 2500 square meters in area and 3 m deep. The northern edge of the lake was dredged for 3 years, ending in the early 1950's. The resulting excavation is in the form of an elongated trough about 4 m deep which is parallel to the main basin (Fig. 2). The trough is isolated from the main basin by a vestige of the marl shelf associated with the original shoreline. Marl at this site was found to be only 4 m deep.

Changes during the period of active marl removal at both the eastern and northern sites are partly documented by a series of aerial photographs obtained from the National Archives and Records Service. Approximately 11% of the present surface area of Lawrence Lake and about 6% of its volume have resulted from marl removal since 1918. Marl dredging still continues at Little Lawrence Lake.

An examination of the current aquatic macrophyte assemblage in Lawrence Lake has given evidence that marl removal has had a drastic effect upon the aquatic flora. The broad marl shelf existing along undisturbed shorelines supports very sparse and stunted patches of *Chara vulgaris, C. globularis, Najas flexilis,* and *Potamogeton gramineus.* Much of the natural marl shelf is entirely barren.

Beyond the 1 m contour, the bottom slopes very sharply downward, and maintains a high angle of descent well beyond the limit of macrophyte growth. From the 1 m contour to 6 m a submerged sedge, the water bulrush (*Scirpus subterminalis*), grows very densely (up to 200 g/m^{2}ash-free dry weight).[2] The nearly pure stand of water bulrush is significantly invaded by another species (*Potamogeton praelongus*) only at a depth of 5 m and below. The *P. praelongus* zone seldom extends below 7 m.

In contrast, dredged areas are generally 3-4 m deep, and support dense stands of *Potamogeton praelongus, P. illinoensis,* and *P. pectinatus.* The absence of the sterile marl shelf also allows aquatics to grow to the shoreline.

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[2]The aquatic vegetation was sampled each month throughout a year by means of a core sampler specially designed for the types of vegetation and bottom material found in Lawrence Lake. Four replicate samples were taken at each 1 m depth interval over four transects in the lake. Biomass for each species was determined on a dry weight and ash-free dry weight basis.

As a consequence of the barren marl shelf and steep sides of Lawrence Lake, the total crop of macrophytes is relatively small. The dominance of the water bulrush limits the invasion and growth of pondweed species still further. However, marl dredging drastically disrupts the typical lake morphology. Thus, the relatively small addition of 11% to the total lake area by marl removal probably represents a significant increase in substrate suitable for aquatic macrophytes and allows a major increase in *Potamogeton* growth.

MISCELLANEOUS ACTIVITIES

Ice was cut from both Lawrence and Little Lawrence Lake from settlement until complete electrification of the Hickory Corners area in 1940.

A sugar bush and sugaring equipment existed south of the lake outlet until 1930.

Intensive muskrat trapping in the area is known during all periods of past habitation. Muskrat activity persists in Lawrence Lake at the present time.

The lake enjoyed a local reputation as a good fishing spot in the past. This reputation may be due to knowledge of some stocking done by a past owner between 1910 and 1925. Species mentioned include warmouth, crappie, yellow perch, bluegills, black bass, and pike. Present fishing effort is minor.

To date, Lawrence Lake has escaped major pollution. Inevitably, the next step in the evolution of human influence upon the lake appears to be nearby residential development.

SUMMARY

Three major patterns of human activity have influenced Lawrence Lake since settlement.

Pioneer agriculture utilized the marshy border of the lake, and evolved into specialized, irrigated crops in the early 20th century. The original tamarack and white cedar were removed during the early stages of settlement.

Large-scale efforts to drain the marsh south of Lawrence Lake were initiated shortly after settlement to extend agricultural sites and to reduce insect vectors of human disease.

Marl removal occurred in three phases. In the 19th century marl was removed and dehydrated for plaster. Early in the 20th century agricultural marl was removed by primitive means, probably in response to the introduction of alfalfa as a field crop. Following the publication of the county soil survey in 1928, marl was removed to a much greater extent and by mechanical means. There is evidence that marl removal has allowed a significant increase in the quantity and diversity of aquatic macrophyte species in Lawrence Lake.

Several human activities having less drastic impact upon the lake are cited.

ACKNOWLEDGMENTS

Much of this account was gathered from personal and telephone interviews either with people directly involved with marl dredging at Lawrence Lake and with shorefront owners, or their relatives. Mr. Curtis Lawrence of Hickory Corners, who supplied most of the information from the 19th century and a great deal from the 20th, is a direct descendent of the first settler, a life-long resident, and a conscientious local historian. His statements were supported in part by photographs, records, and old maps (1860, 1873, 1895) in his possession.

Miss Jenny Greer, who has resided within sight of Lawrence Lake during most of her life and who permits Station personnel free access to the lake over her property, convincingly corroborated Mr. Lawrence on all points. Miss Greer, scarcely more than a generation removed from the hardy people who settled Hickory Corners, exemplifies their incredible health and spirit.

General information concerning Hickory Corners was gleaned from compilations distributed by the Hickory Corners Home-Coming Committee.

Information concerning the morphology and aquatic macrophytes of Lawrence Lake became available in the course of joint efforts under Dr. R. C. Wetzel (Atomic Energy Commission Contract AT(11-1)-1599, COO-1599-23) and from the author's thesis research.

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VASCULAR PLANTS OF THE BRUCE PENINSULA: A REVIEW, WITH COMMENTS AND ADDITIONS

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For the last few weeks I have been reliving over 22 years of enjoying the wild flowers of the Bruce Peninsula of Ontario during many holidays long and short. The Bruce Peninsula lies between Lake Huron and Georgian Bay and has been a mecca for botanists and plant lovers for a century. Being dedicated botanophiles, Mrs. Thomson and I were usually replete with hand lens, camera, and just about every field manual which might help. Above all, our constant companion was "Krotkov," Professor P. V. Krotkov's fine paper, Botanical Explorations in the Bruce Peninsula, Ontario (Trans. Roy. Canad. Inst. 23: 3-65. 1940), published seven months after his death. This paper has an excellent description of the ecology of the Bruce and the important plant associations. It includes an annotated list of 916 different plant taxa representing his collections and a few by others.

It was inevitable that Professor Krotkov would miss some plants, since he made his major trips to the northern and central portions of the Peninsula and actually excluded one of the richest areas, Keppel Township of Grey County, from his region of interest. Since then most workers have considered the Bruce to be more naturally bounded by the highway between the towns

of Southampton and Owen Sound, with minor extensions just east of Owen Sound. This boundary, without the Owen Sound extension, is used in the new Check-List of Vascular Plants of the Bruce Peninsula prepared by the Wildflower Committee of the Federation of Ontario Naturalists.[1] There is a short, good introduction by Peter A. Peach, a geologist, on the botany of the Bruce Peninsula. The new List is stated to be based on Krotkov, without any attempt to check herbarium specimens.

The scientific names in the Check-List are based on M. L. Fernald's eighth edition of *Gray's Manual,* designated "Gray" below. We must differentiate carefully between name equivalencing and Bruce plants. The first is a necessary exercise in botanical semantics–the relationship between the names in Krotkov and in Gray. The authors emphasize that they did not attempt to verify the actual identity of Krotkov's specimens. They give the closest Gray name to the Krotkov name. I think that this was wise since Krotkov relied heavily on Fernald's advice and the identity of Krotkov's plants would be expected to be close to the eighth edition of the *Manual* which was nearing completion at that time. On the other hand about one hundred new plants are in the Check-List, swelling Krotkov's total of 916 (not 915 as he says) to a total of over 1000. For these new plants the scientific names should have been based on the best taxonomic opinion of today, not that of over twenty years ago. Alternative names would have been very useful. Unfortunately no areas or collection citations are given for new entities in the List.

I estimate that at least another thirty entities should be added, so that the Bruce flora includes at least 1040 different kinds of plants. There is good internal evidence that the leading authority on the southeastern Ontario flora, Professor James H. Soper, was not consulted–doubtless he could have added many more.

It would require too much space to list here the 107 plant entities in the Check-List not in Krotkov. (A list of these and of the excluded species would have been very useful.) One at least is really new, *Listera ovata* (L.) R. Br., the Common Twayblade of Europe and Asia, first discovered in North America on the Bruce near the Lake Huron Shore in July 1968. (See Elliott, Ontario Nat. 1/69: 15. 1969).) I can vouch personally for its identity since I photographed it (Figs. 1 & 2) in full blossom on July 9, 1969, and had seen it growing in the Edinburgh Botanic Garden in 1962. There were about twenty plants nearby in various stages of development. On that trip I had taken with me two British floras to check some of the Bruce waifs. The twayblade matched exactly the fine line illustration by John Hutchinson in his *British Wild Flowers* (Vol. II, p. 875. 1955). The plant is enormous compared with our tiny native twayblades, being two to three feet tall with the single pair of leaves about four inches across.

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[1]Check-List of Vascular Plants of the Bruce Peninsula, by Marion S. Shivas, M. D. Kirk, W. K. Kirkwood, & Carol Rolfe. Federation of Ontario Naturalists, 1262 Don Mills Road, Don Mills, Ontario, 1969. 62 pp. $1.50.

Fig. 1. (left). Common Twayblade, *Listera ovata,* near Lake Huron, Bruce Peninsula, Ontario.

Fig. 2. (right). Inflorescence of the same plant. Both photos by George W. Thomson, July 9, 1969.

Seventeen ferns are new, although most have already been noted from the Bruce in the botanical literature. Of note are *Asplenium platyneuron* (L.) Oakes, the Ebony Spleenwort, and *Woodsia Cathcartiana* Robins., Cathcart's Woodsia. Fern students would have appreciated approximate localities or collection records of these rarities. There will probably be more records for the Moonworts, *Botrychium* spp., and the Wood Ferns, *Dryopteris* spp., when Dale J. Hagenah completes his studies, since he has more field knowledge of the Bruce ferns than anyone else. The *Dryopteris* hybrids have been extensively studied on the Bruce by Mr. Hagenah and by Dr. D. M. Britton, who "checked" the ferns of the Check-List. However, these hybrids are not even hinted at. Britton even gives the old Gray name for *Dryopteris spinulosa* var. *fructuosa* although he has discussed it as the hybrid *D. intermedia* × *spinulosa* in other publications. There are a number of other slips and technical errors in the fern section reflecting the dependence on only translating the names to Gray and the difficulty of relating the results of recent research to plants in the field. The distinctive hybrid between the Northern Holly Fern and the Christmas Fern, *Polystichum* ×*Hagenahii* W. J. Cody (Am. Fern Jour. 58: 30. 1968) was named from material collected on the Bruce by Dale Hagenah and W. H. Wagner, Jr. Note that the name of the Lady Fern, according to Gray, should be var. *Michauxii* (Spreng.) Farwell and not the species itself as shown on p. 10 of the List.

Before leaving the ferns I must point out the most astonishing omission of them all. *Schizaea pusilla* Pursh, the Curly-Grass Fern, was collected in July, 1928, by a keen-eyed moss expert, E. A. Moxley, in an area now built up with cottages at Sauble Beach. This record is noted in Gleason's edition of Britton and Brown's *Illustrated Flora* but not in Gray. The information was not known to Krotkov since the collection was not published until 1945 (Am. Fern Jour. 35: 40). Perhaps this tiny fern will be found again since there is no doubt either of its identity or of the exact location where it was collected.

The Bruce has been famous for a century as a rich orchid area. Krotkov has 28, the Check-List has 38, and Fred Case's recent book, *Orchids of the Western Great Lakes Region* (Cranbrook, 1964) shows 33 from the Bruce. The new items in the List not shown on Case's maps are *Spiranthes gracilis* (Bigel.) Beck, Slender Ladies Tresses; *Malaxis unifolia* Michx., Green Adder's Mouth Orchid; *Listera ovata,* discussed above; a color form of Spotted Coral-root; and the doubtful *Habenaria media* which is often said to be the cross between *H. dilatata,* Tall White Bog Orchid, and *H. hyperborea,* Tall Northern Green Orchid. These intergrade so much in the field that *H. media* is usually rejected as a worthless name. The Check-List also accepts *H. macrophylla*, as did Krotkov, which many orchid specialists including Case and Correll believe to be a larger form of *H. orbiculata,* Large Roundleaved Orchid or Dinner Plate Orchid, as we call it on our Michigan Botanical Club field trips. A strange omission is *Spiranthes cernua* (L.) Richard, Nodding Ladies Tresses, which many of us have seen and which is mapped from the Bruce in Case. If the boundaries of the Bruce are stretched to a few miles east of Owen Sound, yet another orchid can be added. The Hagenahs have found a good stand of

Orchis spectabilis L., Showy Orchis, there and we would expect to find it in similar habitats to the west.

The following are among the other entities in the Check-List which are not in Krotkov: *Trillium cernuum,* Nodding Trillium; *Ranunculus flabellaris,* Yellow Water Crowfoot; *Menispermum canadense,* Moonseed; *Corydalis sempervirens,* Pale Corydalis; *Saxifraga Aizoön* var. *neogaea,* called the "Yellow Mountain Saxifrage" in the List although this name is generally applied to *S. aizoides,* while "Encrusted Saxifrage" has been used for *S. Aizoön; Sorbaria sorbifolia,* False Spiraea; *Pterospora andromedea,* Pine Drops; *Centaurium umbellatum,* Centaury; *Myosotis verna,* White Forget-me-not; *Hedeoma pulegioides,* American Pennyroyal; *Conopholis americana,* Squaw Root; *Veronica longifolia,* Longleaved Speedwell; *Veronica officinalis,* Common Speedwell; *Penstemon Digitalis,* Foxglove Beardtongue; *Campanula rapunculoides,* Creeping Bellflower; *Actinea herbacea,* Stemless Rubber Weed; *Grindelia squarrosa,* Gumweed; *Tragopogon porrifolius,* Common Salisify or Purple Goatsbeard; *Tussilago Farfara,* Coltsfoot. These are splendid additions to the flora. I have seen only a few of them and am looking forward to finding the others.

About ten entities have been dropped from Krotkov; in other words, I could not find a corresponding item in the Check-List. *Potamogeton longiligulatus* Fern., a Pondweed; *Oryzopsis pungens* (Torr.) Hitchcock, a Rice Grass; *Smilax rotundifolia* L., Common Greenbrier; *Populus tremuloides* var. *intermedia* Vict., a variety of the Quaking Aspen not maintained in Gray and var. *magnifica* Vict., not only given in Gray (p. 522) but mentioned as from the Bruce (!); *Betula microphylla* Bunge, an arctic and western Birch not in Gray but collected in northern Canada by Hugh Raup; *Apocynum sibiricum* var. *salignum* (Greene) Fern., the western extreme of Clasping-leaved Dogbane, not in Gray; *Chaenorrhinum minus* (L.) Lange, which I have found in Wiarton; *Inula Helenium,* Elecampane, common along roadsides south of Wiarton; *Solidago altissima,* Tall Goldenrod. I believe that these items apparently omitted in transcribing the Krotkov list should be included in the Check-List when a new edition appears.

Listed below are some plants which are included neither in Krotkov nor in the Check-List, but which I have seen. I have also included some shrubs recorded as growing on the Bruce on the maps by Soper and Heimburger (100 Shrubs of Ontario, 1961); these are marked "S,H" below. Many of the plants have been noted by our friends and associates in the Michigan Botanical Club, not only on innumerable short trips, but also during our expeditions over the entire peninsula in 1957, 1958, and 1959 (with 40 to 50 each time) and on our memorable State meeting in 1966 attended by 199 members.

Lycopodium complanatum var. *flabelliforme* Fern., Running Ground-Pine. The common form in the rich dune forests of Sauble Beach, etc.

Claytonia virginica L., Common Spring Beauty. This narrow-leaved species is often seen with the commoner *C. caroliniana* Michx. in rich hardwoods.

Ranunculus bulbosus L., Bulbous Buttercup, is widespread both along roadsides and in open woods.

Ranunculus trichophyllus Chaix, Hairleaved Water Crowfoot, was seen once in a muddy stream near Lindenwood. These were not *R. longirostris* Godr., which is listed in Krotkov.

Clematis verticillaris DC., Purple Clematis. (S,H)

Lindera Benzoin (L.) Blume, Spice Bush. (S,H) We have seen it many times in rich mixed woods.

Berberis vulgaris L., Common Barberry. (S,H) Only found in the wild occasionally. A sturdy plant with very large leaves and spines was seen in a rocky pasture in the shelter of large dolomite blocks, not near a farm house, east of Clavering.

Berberis Aquifolium Pursh, Mahonia; Oregon Holly Grape. A very large bush about 15 feet in width is flourishing and reseeding on an abandoned farm site southwest of Lindenwood.

Erucastrum gallicum (Willd.) O. E. Schulz, Dog Mustard. A tumbleweed mustard pointed out by Dr. E. G. Voss of the University of Michigan on our 1966 expedition. He said it was becoming widespread around the Great Lakes. Since then we have seen it at many places along the Huron shore.

Hesperis matronalis L., Dame's Rocket. An abundant plant throughout on shores, talus, and roadsides.

Dentaria laciniata Muhl., Cutleaved Toothwort. Plentiful in rich woods north of Kemble.

Barbarea vulgaris R. Br., Yellow Rocket. Plants along the roadsides near Johnson Harbour were not *B. orthoceras.*

Ribes Cynosbati var. *atrox* Fern., Bristly Gooseberry. (S,H) We have seen it at many places in the northern part of the Bruce. Type locality is Manitoulin Island.

Ribes triste var. *albinervium* (Michx.) Fern., glabrous form of Wild Currant. Much commoner than the hairier form.

Ribes odoratum Wendland f., Golden Currant, and *R. glandulosum* Grauer, Skunk Currant. Both S,H.

Trifolium procumbens L., Low Hop Clover. Many Bruce specimens checked were not *T. agrarium* L. Both species are common along roadsides in gravel on both sides of the Peninsula.

Gleditsia triacanthos L., Honey Locust. There are old planted trees on the Big Bay Road near Owen Sound.

Euphorbia marginata Pursh, Snow-on-the-mountain. Well established escape, Oliphant Cemetery and elsewhere.

(Two spurges noted in the Check-List, *E. Cyparissias* L., Cypress Spurge, and *E. Esula* L., Leafy Spurge, are dominating large areas of the sandy fields north of Sauble Beach and are appearing elsewhere.)

Euonymus atropurpureus Jacq., Burning Bush. Rich woods on lower talus slopes, Sydney Bay.

We have all sorts of other escapes, so let us include *Althaea rosea* Cav., Hollyhock.

Viola renifolia Gray, Hairy Kidneyleaved Violet. The densely pubescent form is common in similar wet wood habitats with var. *Brainerdii* (Greene) Fern., the almost glabrous form mentioned in the Check-List.

Viola rostrata Pursh, Longspurred Violet, in rich wet woods with *V. conspersa* Reichenb., Dog Violet.

Aegopodium Podagraria L., Bishop's Goutweed. A bad garden escape, long persistent.

Levisticum officinale W. D. J. Koch, Lovage. An astonishing omission from the Check-List. The plants at the Big Bay Dock and nearby at North Keppel have been flourishing since the village was founded about a hundred years ago. They are known to all the members of the Michigan Botanical Club who have visited the Bruce.

Pyrola rotundifolia L., Roundleaf Pyrola. Noted on Flowerpot Island. Not var. *americana* (Sweet) Fern.

Kalmia polifolia Wang., Bog Laurel. (S,H)

Vinca minor L., Myrtle or Common Periwinkle, is well established as a ground cover in Wiarton and other built-up areas.

Myosotis scorpioides L., Forget-me-not. Wet sand and beaches with *M. laxa* Lehm.

Hackelia virginiana (L.) Johnst., Beggar Lice. Dock at Little Port Elgin, Cape Croker.

Ajuga reptans L., Bugle. A well-established garden weed and escape, Colpoy's Bay.

Thymus serpyllum L. (sensu Amer. authors), Wild Thyme. A garden escape noted at Red Bay, Cabot Head, and in other locations where it is well established often far from habitations.

Orobanche fasciculata Nutt., Bunched Cancer Root. Photographed at Dorcas Bay. Also found on Manitoulin Island.

Veronica peregrina L., Neckweed. A white speedwell common in the grass near the shore at Hope Bay.

Viburnum cassinoides L., Witherod, and *Lonicera villosa* (Michx.) R. & S., Mountain Fly-Honeysuckle. (Both S,H.)

This brings us to the Compositae. The most striking omission is the low yellow matformer, *Hieracium Pilosella* L., Mouse-ear Hawkweed, which grows by the millions, covering entire fields, in Keppel Township. Several of the rare Moonworts (*Botrychium* spp.) listed in the Check-List, perhaps from Dr. D. M. Britton's records, grow hidden among this hawkweed!

Another bad pest of this marginal soil is *Carduus acanthoides* L., a spiny thistle with a characteristic "skinny" look. A good common name might be Acanthus Thistle; the Keppel farmers have a better one, I'm sure.

Cirsium muticum Michx., Swamp Thistle, is in the Sauble Beach area.

Lapsana communis L., Nipplewort, is becoming an active invader of roadsides and disturbed places. I have seen plants six feet high in Owen Sound.

Another hawkweed which is said to be having a population explosion around the Great Lakes is *Hieracium florentinum* All., King Devil. Only a few

of the big yellow hawkweeds turn out to be this species, but we did see it at Berford Lake. Much more worthy of the name King Devil is the other big yellow one, *H. pratense* Tausch, Field Hawkweed (in the Check-List as a new item), which often grows with the ubiquitous Mouse-ear Hawkweed.

Everybody notices *Bellis perennis* L., English Daisy, in the Wiarton lawns but somehow or other it got left out of the Check-List.

Tragopogon major Jacq., Pale Yellow Goatsbeard, is the commonest of the three salsifies found on the Bruce. Also known as *T. dubius* Scop., it can be easily distinguished from *T. pratensis* L., which we call the Orange Goatsbeard. All three species are common roadside plants. None of the hybrids described by Hall, Persell, and Thompson (Mich. Bot. 5: 79-91. 1966) have been noted.

Solidago hispida var. *tonsa* Fern. (Gray, p. 1393), the almost completely glabrous form of the Hairy Goldenrod, has apparently been included in var. *arnoglossa* Fern. in Gleason's *Illustrated Flora* (III, p. 420). It is a very northern form which is the principal goldenrod in the dolomite crevices in exposed wet places like the rocks near the Tobermory lighthouse.

Although we have seen and photographed it in northern Michigan, we have looked for and not yet found in the Bruce the famous Upper Great Lakes disjunct, *Adenocaulon bicolor* Hook., Trail Plant. It was collected by A. Y. Massey in 1895 on the Cape Croker Indian Reserve. Gray (p. 1465) cites it from the Bruce. Let us hope that the next edition of the Check-List will include *Adenocaulon* as well as *Schizaea.*

In closing, I believe that the Check-List will be of great value to both botanists and botanophiles. Its worth will be enhanced when the authors are able to add the many other records of the numerous people who have studied and enjoyed the plants of the Bruce for over a century.

Publications of Interest

[See also page 63]

NATURAL DYES IN THE UNITED STATES. By Rita J. Adrosko. U. S. National Museum Bulletin 281, 1968. 160 pp. $3.25, clothbound (Supt. of Documents, Govt. Printing Office, Washington 20402). Part 1 (53 pp.) is on dyestuffs used in America during the 18th and 19th centuries; part 3 is on home dyeing with natural dyes. The appendixes are chiefly historical, presenting accounts and recipes from early American dye literature.

NIGHTSHADES The Paradoxical Plants. By Charles B. Heiser, Jr. W. H. Freeman & Co., San Francisco, 1969. $5.95. A popular account, for the general reader, of the nightshade family (Solanaceae), including potatoes, tomatoes, hot peppers, tobacco, Luther Burbank's "Wonderberry," mandrake, belladonna, and other edible, poisonous, or ornamental members.

THE GENUS *PANELLUS* IN NORTH AMERICA

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The genus *Panellus* has been thoroughly studied in Europe and the species clearly delimited by Kühner and Romagnesi (1953), Moser (1967), Singer (1962), and others. The species have been individually studied in North America and variously reported by Kauffman (1918), Groves (1962), Krieger (1947), and Murrill (1915) under *Pleurotus, Panus,* and other taxa. However, the use of the amyloid reaction in connection with a systematic restudy of the morphology of the basidiospores and the sporocarp of the North American species has not been undertaken. The object of this study is to examine the North American taxa which might be included in *Panellus,* and to report on the number, distribution, and ecology of the North American species. Keys are provided which utilize among others many new or previously unused characters to aid in the identification of fresh and dried specimens.

Photomicrographs were taken with a Leitz Orthomat camera mounted on a Leitz-Ortholux research microscope. The line drawings were made with the aid of camera lucida. Ridgway (1912) colors are indicated in quotation marks, e.g., "snuff brown." The location of each collection studied is indicated by the standard herbarium designation, e.g., (MICH), following the collection number.

PANELLUS P. Karst. Bidr. Känn. Finl. Nat. Folk 32: XIV. 96. 1879.

Pileus 8-45 (-100) mm broad, 5-35 mm wide, viscid to dry, glabrous to woolly-pubescent, smooth, white, green, brown, or violaceous. Lamellae close to subdistant, even, edges entire, white, pinkish-buff, ochraceous, olivaceous, to vinaceous or brown. Veil present on young sporophores of one species. Stipe present or absent, if present very short (1-12 mm) and eccentric or laterally attached, dry, minutely pubescent or fibrillose, concolorous with the pileus. Sporocarps revive when moistened. Taste mild to slightly acrid. Odor not distinctive.

Spores 3.0-7.0(-11.0) × (0.5-)1.0-2.0(3.5) μ, allantoid, oblong, cylindric to narrowly elliptical, smooth, thin-walled, *amyloid* (blue to purple in Melzer's solution); spore print white to yellow. Basidia small, 11-28 × 2.5-4.2(-6.3) μ, clavate, thin-walled, 4-spored, hyaline in KOH and Melzer's solution. Cheilocystidia cylindric, fusiform, clavate to bifurcate or irregularly shaped, *thin-walled,* hyaline, embedded to protruding, abundant to infrequent. Pleurocystidia present or absent, when present similar to cheilocystidia. Pileocystidia usually present, typically long, narrow, thin- or thick-walled, and single or in fascicles. Cuticle either a gelatinous pellicle (Fig. 27) or of interwoven thick- and thin-walled hyphae (Figs. 28, 29). The latter usually with hairs (pileocystidia) but sometimes aggregated into fascicles appearing hispid. Trama of pileus of two types: 1. duplex with an upper gelatinous zone and a lower

zone of interwoven, non gelatinous, thick- and thin-walled hyphae; 2. homogeneous, of interwoven thick- and thin-walled hyphae. Trama of the lamellae of interwoven usually thick- and sometimes thin-walled hyphae. Clamp connections are present in all species.

Habit, habitat, and distribution.—Imbricate, often very crowded (e.g. Fig. 34), rarely single, always on twigs, branches, logs, and stumps of woody plants. Most commonly found on hardwoods but occasionally on conifers, noted especially on *Betula, Salix, Populus, Alnus, Quercus, Tsuga, Picea,* and *Pinus.* Fruiting from midsummer in the boreal forests to fall in the temperate forests. Known from Europe, North America, South America, Asia, Australia, and New Zealand.

Observations.—The genus *Panellus* is a lignicolous group of white- to yellow-spored species in the Tricholomataceae. It differs from all other genera by having a combination of amyloid, smooth, allantoid to narrowly elliptical spores; thick-walled hyphae in the trama of the lamellae (see Figs. 4, 10); even gill edges; a sessile to short-stipitate fruiting body; and thin-walled cheilocystidia. Specimens revive when moistened and could be confused with *Lentinellus, Phyllotopsis,* and *Plicaturopsis. Lentinellus* has short elliptical to subglobose amyloid spores but the serrate gill edges, cellular cutis, amyloid pileus trama in some species, and lack of gelatinous tissue separate it from *Panellus.* The nonamyloid, allantoid spores of *Phyllotopsis,* which are pink in deposit, are distinctive. *Plicaturopsis* appears closely related to *Panellus* but its allantoid spores are nonamyloid, the lamellae are often discontinuous or reduced to veins, and it has distinctive basidia constricted near the apex (Reid, 1964).

Type: *Panellus stipticus* (Bull. ex Fr.) Karst.

KEY TO THE SPECIES OF *PANELLUS*

1. Pileus viscid, with a thin pellicle (Fig. 27), glabrous or with pileocystidia (Fig. 28), brown to green; upper trama a thick refractive, gelatinous layer; with or without a veil when young; usually on hardwoods 2
1. Pileus dry or moist, white, violaceous to brown; if brown distinctly stipitate; cuticle with pileocystidia and/or loosely interwoven hyphae; lacking a veil; on hardwoods or conifers 3
   2. Pileus small (8-15 mm broad), brown, villose to fibrillose in age; a thin-membranous veil (Fig. 32) present on young sporophores but absent at maturity; cheilocystidia (3.5-5.0 μ wide, Fig. 3), pleurocystidia absent . . . . . 1. *P. patellaris*
   2. Pileus large (25-100 mm broad), slimy viscid when moist, green to dark olive-green (drying green); veil absent; cheilocystidia and pleurocystidia abundant (6.5-12 μ wide, Figs. 7, 8) . . . . . 2. *P. serotinus*
3. Pileus small (5-10 mm), moist, white (drying white), with a thick gelatinous upper trama; gelatinous gill edge (Fig. 31) furnished with small contorted cheilocystidia 12-19 × 3.2-7.6 μ (Fig. 13); always on conifer wood . . . . . 3. *P. mitis*
3. Pileus larger (10-35 mm), violaceous to brown; pileus trama and gill edge not gelatinous; on hardwoods and conifers 4
   4. Pileus tan, distinctly laterally stipitate; cheilocystidia abundant, protruding, narrow, 18-45 × 2.5-6.0 μ (Fig. 19); spores elliptical to weakly allantoid in profile (Fig. 17); abundant and common on many hardwoods . . . . . 4. *P. stipticus*
   4. Pileus violaceous, sessile; cheilocystidia infrequent, embedded; spores allantoid to oblong; often on birch, willow, alder, and conifers (usually spruce) 5

5. Spores (4.5-)5.0-6.5(-7.5) × 1.2-2.0 μ; lamellae not distinctly intervenose; usually on hardwoods; common in Europe and North America . . . . . 5. *P. ringens*
5. Spores 6-11 × 2-3.5 μ; lamellae conspicuously intervenose; usually on conifers; known from eastern Canada and Europe. . . . . 6. *P. violaceofulvus*

1. *Panellus patellaris* (Fr.) Konr. & Maubl. Figs. 1-4, 27, 32.
Icon. sel. fung. VI. p. 379. 1924.

Panus patellaris Fr. Epicr. p. 400. 1838.

Pileus 8-15 mm broad, sessile to short-stipitate, convex, viscid to glutinous at first, soon becoming fibrillose to villose and moist to dry, brown, "snuff brown." Context a narrow water-soaked brown ("sayal brown") layer just beneath the gelatinous cuticle, remainder of context of pileus and stipe of firm pale cinnamon ("pale pinkish cinnamon") tissue. Stipe when present 1-3 mm long, 0.5-1.5 mm wide, eccentric, equal, dry, usually somewhat curved. Lamellae subdistant, narrow, "cinnamon-buff," covered at first by a thin membranous, dry "pinkish buff" veil which soon disappears leaving no traces at maturity.

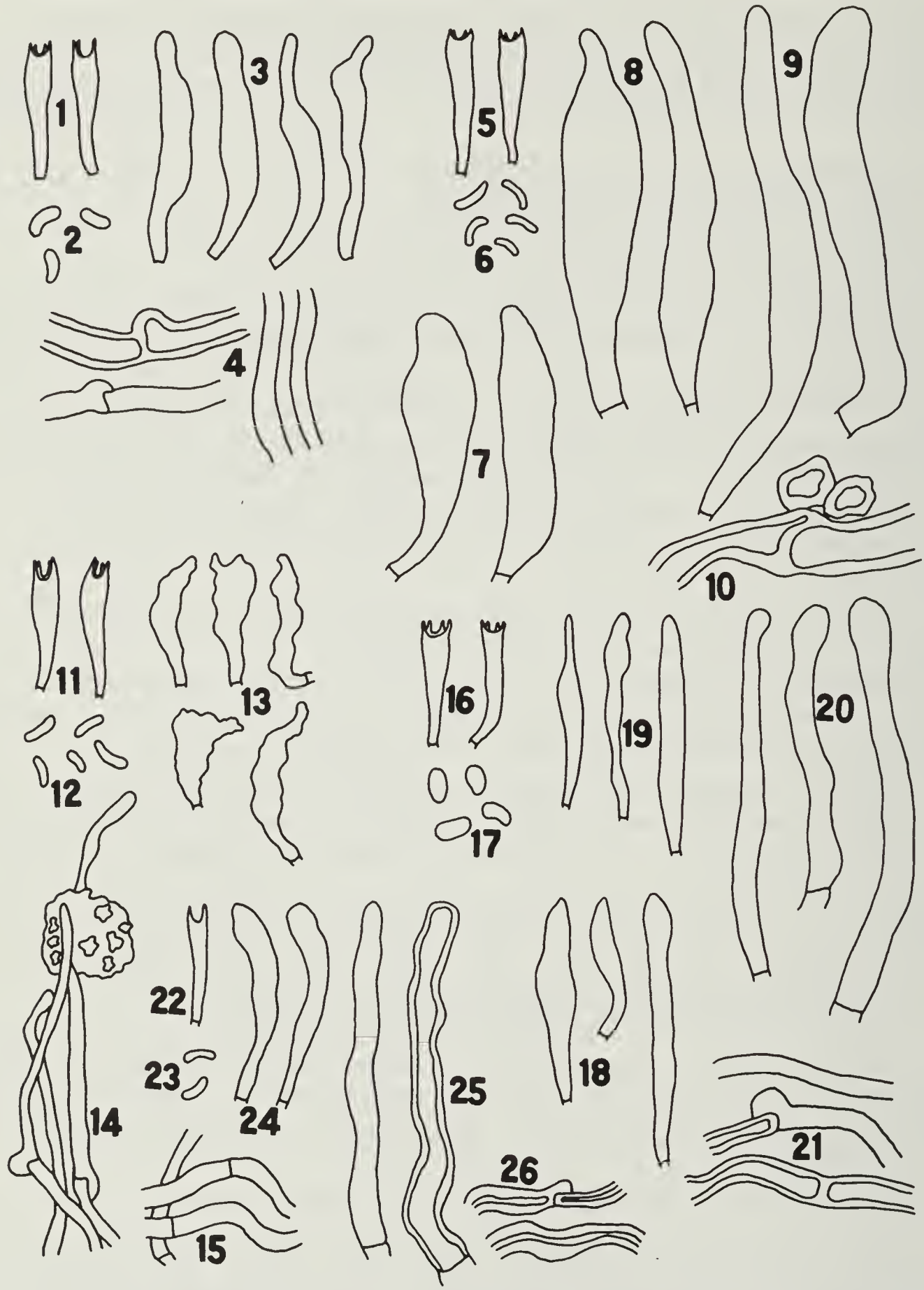
Spores 4.5-5.5 × 0.5-1.5 μ, allantoid, thin-walled, amyloid (light blue in Melzer's solution); spore print white. Basidia 17-28 × 3.5-4.2 μ, narrowly clavate, 4-spored. Cheilocystidia 22-35 × 3.5-5.0 μ, clavate to fusiform, thin-walled, hyaline with some yellowish contents in KOH and Melzer's solution, protruding 1/3 to 1/2 of total length. Pleurocystidia—none seen.

Cuticle of pileus a thick gelatinous layer of interwoven hyphae 1.5-3.5 μ diam., thin-walled, clamps frequent, hyaline except for a thin pigmented zone near the surface; trama of pileus of interwoven hyphae 2.5-3.5 (-4.5) μ diam., thin-walled, clamps frequent, yellow to brown near cuticle, otherwise yellowish to hyaline in KOH or Melzer's solution. Trama of lamellae of interwoven hyphae 2.5-4.5 μ diam., thin- and thick-walled (walls up to 1.5 μ thick), hyaline to yellowish in KOH and Melzer's solution.

Habit, habitat, and distribution.—Solitary, imbricate, or even in caespitose clusters on dead branches or on fallen twigs. Branches usually not decorticated. Noted on species of *Alnus, Betula, Salix,* and *Fagus.* Widespread in Europe and North America but encountered infrequently. Fruiting from July to October.

Observations.—*P. patellaris* is the only member of the genus with a veil. At maturity the veil has disappeared and one must then look for the combination of a viscid cuticle, gelatinous upper trama, narrow cheilocystidia, small size, and brown coloration. *P. serotinus* is the other pigmented species with a viscid cuticle, but it is much larger, lacks a veil, has wide cheilocystidia and pleurocystidia, and the pileus is green to olivaceous when fresh. Fresh spore prints (Miller, 1968) were used to demonstrate the amyloid spore wall.

Material examined.—Canada: Ontario; R. F. Cain & A. H. Smith 4118 (MICH), L. Overholts 18603 (MICH). Yukon Terr.; O. K. Miller 5547 (BFDL). U.S.A.: Maine; F. L. Harvey 2010 (MICH). Michigan; D. V. Baxter & C. H. Kauffman Aug. 18, 1922 (MICH), A. H. Smith 22308 (MICH), D. E. Stuntz 5508 (MICH). New York; Man. 1884 (NY).



Figs. 1-4. *Panellus patellaris.* 1. Basidia. 2. Basidiospores. 3. Cheilocystidia. 4. Hyphae in the trama of the lamellae.
Figs. 5-10. *P. serotinus.* 5. Basidia. 6. Basidiospores. 7. Pleurocystidia. 8. Cheilocystidia. 9. Pileocystidia. 10. Hyphae in the trama of the lamellae.
Figs. 11-15. *P. mitis.* 11. Basidia. 12. Basidiospores. 13. Cheilocystidia. 14. Pileocystidia. 15. Hyphae in the trama of the lamellae.
Figs. 16-21. *P. stipticus.* 16. Basidia. 17. Basidiospores. 18. Pleurocystidia. 19. Cheilocystidia. 20. Pileocystidia. 21. Hyphae in the trama of the lamellae.
Figs. 22-26. *P. ringens.* 22. Basidium. 23. Basidiospores. 24. Cheilocystidia. 25. Pileocystidia. 26. Hyphae in the trama of the lamellae.

(Figs. 1-26 ×750)

2. *Panellus serotinus* (Pers. in Hofmann ex Fr.) Kühner Figs. 5-10, 33.
Fl. Analytique Champ. sup. p. 67. 1953.

Agaricus serotinus Fries, Syst. Mycol. 1: 187. 1821.

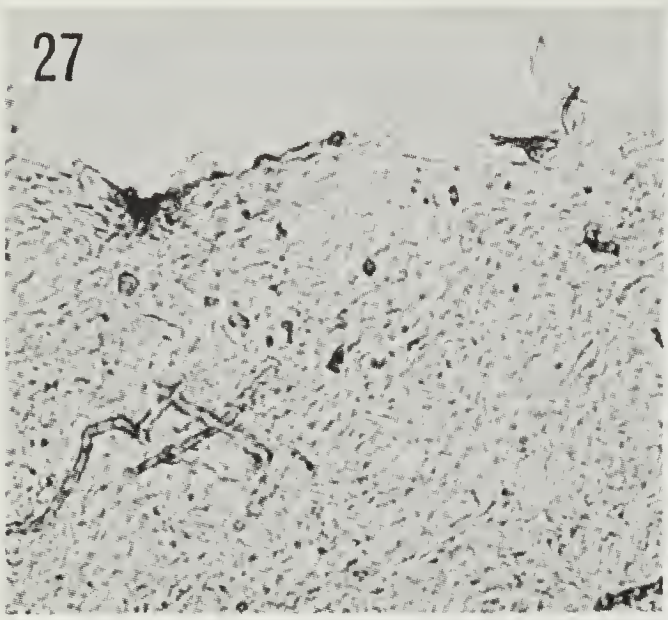
Pileus 2.5-6.0(-10.0) cm broad, 2.0-3.5 cm wide, convex, fan-shaped, conchate; margin often lobed or wavy, viscid, "vetiver green," "olive ochre" to "deep colonial buff" rarely ochraceous in center to "dark greenish olive," "dark ivy green," "citrine drab" to "dark olive buff" occasionally toned purple over the margin, always sessile. Lamellae close to subdistant, narrow, even, clearly marginate, pale orange to "honey yellow" with "yellowish olive" to "brownish olive" rarely "cinnamon buff" on the margin.

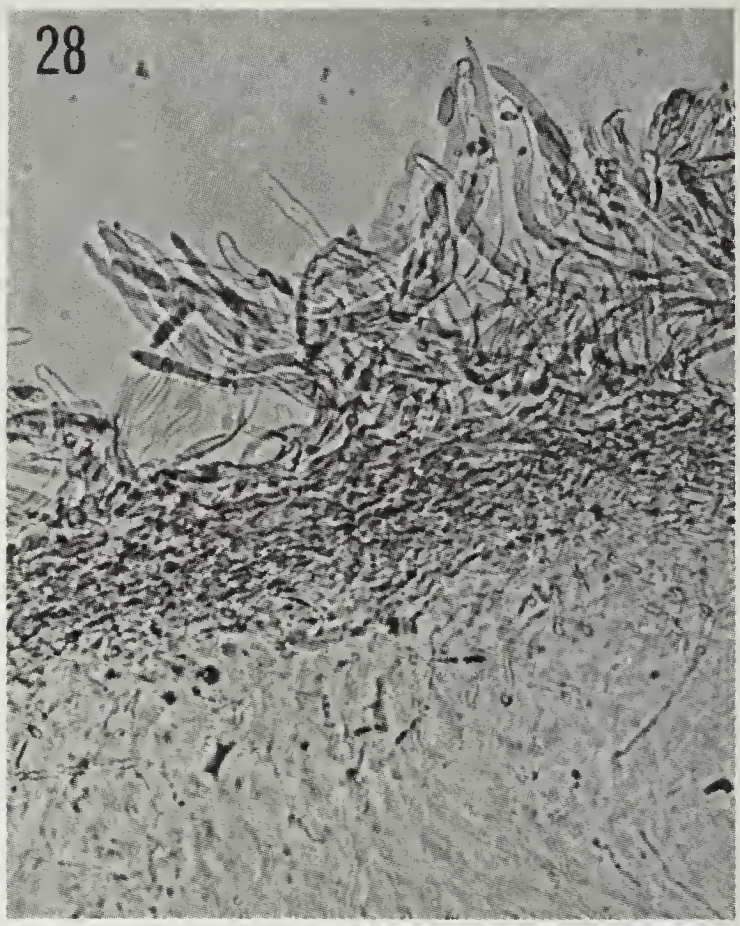
Spores 4.0-5.5 × 1.0-1.5 μ, allantoid to cylindric, with amyloid (blue) walls and yellow contents in Melzer's solution; spore print yellow. Basidia 17-21 × 3.0-4.0 μ, narrowly clavate, 4-spored. Pleurocystidia 35-64 × 6.5-11 μ, fusiform, broadly fusiform, to clavate, thin-walled, sometimes with incrustations over the apex, hyaline in KOH, yellowish in Melzer's solution, frequent, projecting up to 1/2 of total length. Cheilocystidia 40-60 × 6.5-12 μ, nearly cylindric, fusiform to narrowly clavate, thin-walled, hyaline in KOH, yellowish in Melzer's solution, abundant, projecting 1/2 to 3/4 of total length. Cuticle with numerous tangled or decumbent, nearly cylindric, fusiform to long-clavate, thin-walled pileocystidia 50-90 × 6-9 μ with yellow contents in Melzer's solution, hyaline in KOH, olive in H_2O, and arising from a thin cutis composed of interwoven thin- and thick-walled hyphae 2.5-8.5 μ diam., the hyphae yellow in Melzer's solution, hyaline in KOH. Trama of pileus duplex with an upper gelatinous layer containing interwoven, thin-walled hyphae 1.5-3.5 μ diam. and is often folded or partially gelatinized. Lower trama of non gelatinous, interwoven, thin- and thick-walled hyphae 3.5-18.0 μ diam., bearing clamp connections, dingy yellow-brown in Melzer's solution, light yellowish in KOH. Trama of lamellae of loosely interwoven, mostly thick-walled hyphae 2.5-11.0 μ diam., yellowish in Melzer's solution, light yellowish in KOH.

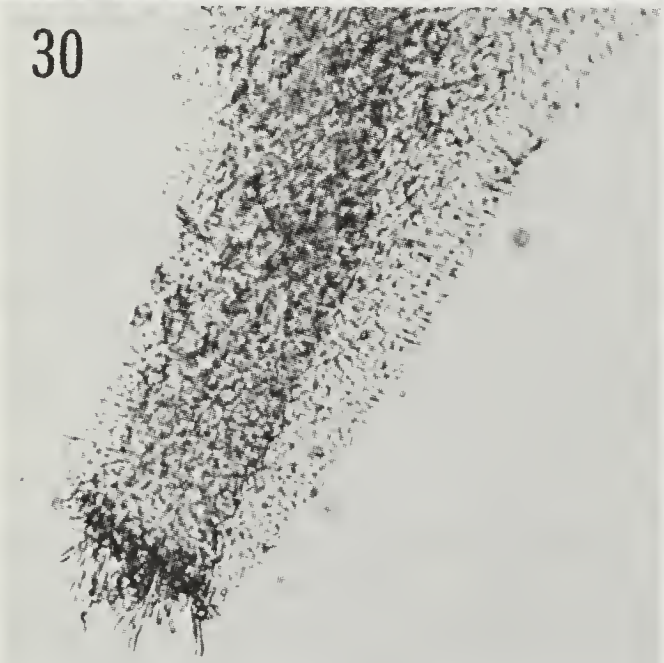
Habit, habitat, and distribution.—Occasionally solitary but usually imbricate on the sides of logs and sticks of various hardwoods and conifers, usually before they become decorticated. Noted on *Alnus, Populus, Ulmus, Fagus, Betula,* and *Quercus,* but also on *Tsuga heterophylla* in the western United States. Fruiting in the fall especially during late September and October. Widely distributed throughout North America, Europe, and Asia.

Observations.—This robust species has a characteristic greenish to olivaceous color of the pileus, is viscid when fresh, and has numerous tangled pileocystidia (Fig. 28). This combination of characters is distinctive in *Panellus.* Herbarium specimens without notes could be recognized by the combination of long, broad, pleurocystidia and cheilocystidia; the distinctive pileocystidia; and the thick gelatinous cuticle.

Material examined.—U.S.A.: California; A. H. Smith 56323 (MICH), 56773 (MICH). Idaho; O. K. Miller 1472 (BFDL), 2222 (BFDL), 2248 (BFDL), 2081 (BFDL), 2851 (BFDL), 2890 (BFDL), 2917 (BFDL). A. H. Smith 53899 (MICH), 54585 (MICH), 54601 (MICH), 55247 (MICH), 55299 (MICH), 67702 (MICH), 70927 (MICH), 71033







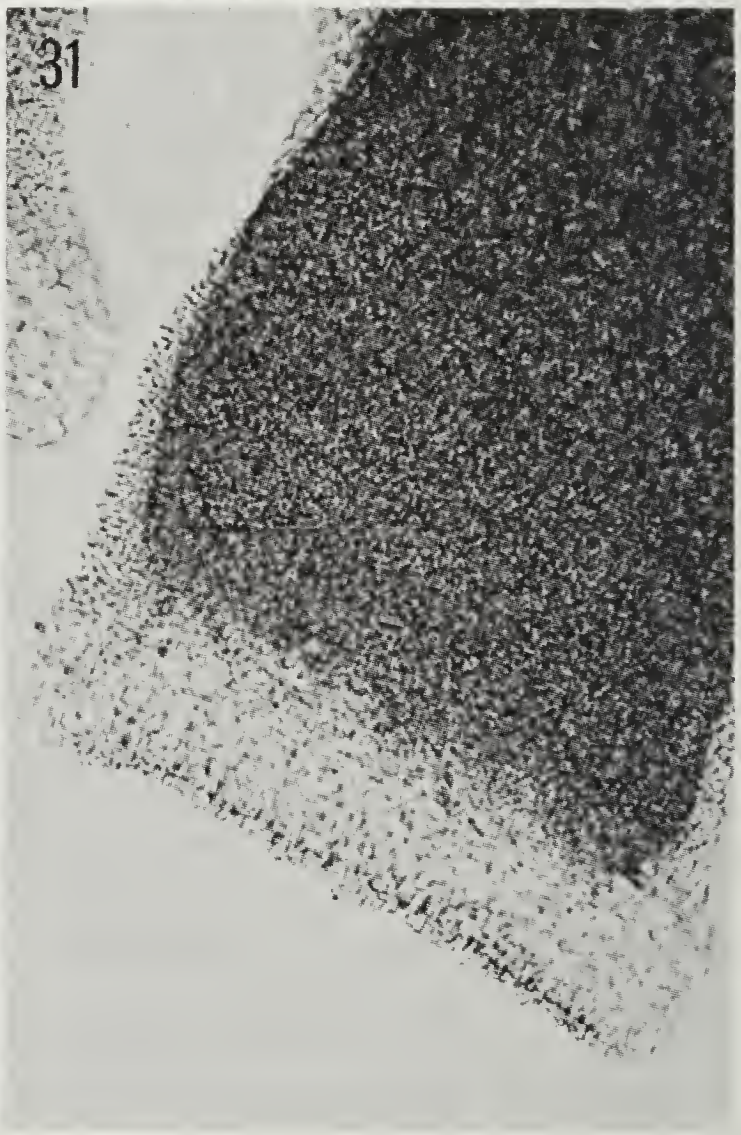


Fig. 27. Viscid cuticle of *P. patellaris.* Fig. 28. Viscid cuticle of *P. serotinus* with tangled pileocystidia. Fig. 29. Dry cuticle of *P. stipticus,* a dense tangle of thick- and thin-walled hyphae. Fig. 30. Elongate cheilocystidia in *P. stipticus.* Fig. 31. Gelatinous edge of lamella on *P. mitis.*

(MICH), 76559 (MICH), 76946 (MICH). J. R. Weir and A. S. Rhoads F.P. 38593 (BFDL). Michigan; O. K. Miller 131 (BFDL); A. H. Smith 43864 (MICH), 44063 (MICH), 50995 (MICH), 58322 (MICH), 58360 (MICH), 60809 (MICH), 62042 (MICH), 62043 (MICH), 62063 (MICH), 62210 (MICH), 62359 (MICH), 62394 (MICH), 64754 (MICH), 75227 (MICH). Montana; J. R. Weir F. P. 11348 (BFDL), F. P. 11411 (BFDL). New Hampshire; P. Spaulding F.P. 2318 (BFDL). North Carolina; G. C. Hedgecock F.P. 55086 (BFDL). Canada: British Columbia; O. K. Miller 4856 (BFDL).

3. *Panellus mitis* (Pers. ex Fr.) Sing. Figs. 11-15, 31, 35.
Ann. Mycol. 34: 334. 1936.

Agaricus mitis Pers. ex Fr., Syst. Mycol. 1: 188. 1821.

Pileus 5-8 mm long, 5-6 mm wide, spathulate to conchate, flat to broadly convex, a dull white ground color, covered with a fine white canescence from appressed fibrils (best seen with a handlens). Lamellae subdistant, even, narrow, white to pale pinkish cinnamon. Stipe 1-2 mm long, 1 mm or less wide, laterally attached, covered with minute white fibrils over a pallid ground color.

Spores 3.5-6.0 × 0.9-1.2 (-1.5) μ, allantoid to cylindric, smooth, thin-walled, amyloid (purple in Melzer's solution). Basidia 11-22 × 2.5-3.5 μ, narrowly clavate, 4-spored. Cheilocystidia 12-19 × 3.0-7.6 μ, fusiform, clavate to contorted and irregular, thin-walled, hyaline in KOH and Melzer's solution, projecting somewhat or embedded in the sterile gelatinous layer which covers the edges of the lamellae. Cuticle with long, thin-walled hairs (1.5-3.5 μ wide) solitary or in loose often tangled fascicles, hyaline, often with a basal clamp connection. Trama of the pileus duplex with a wide (300-400 μ) gelatinous upper layer, composed of gelatinous hyphae (1.5-3.5 μ wide) embedded in a refractive, hyaline matrix; lower layer non gelatinous, of interwoven, thin-walled hyphae (2.5-7.0 μ, in diam.), ochraceous in Melzer's solution, dingy yellowish brown in KOH. Trama of lamellae of interwoven hyphae similar to the lower trama of the pileus, with the exception of the edge which is composed of a broad gelatinous layer containing gelatinous hyphae.

Habit and habitat.—Usually scattered or in clusters along the sides of conifer logs and sticks; particularly abundant on western larch (*Larix occidentalis*). Fruiting in the fall especially during September and October in Europe and North America.

Observations.—The small white sporocarps containing a gelatinous upper layer in the pileus trama and at the gill edges (Fig. 31) combined with the unusual cheilocystidia (Fig. 13) are a combination of characters which is possessed by no other species of *Panellus*.

Material examined.—Canada: B.C.; A. Foster 44413 (DAOM), 44474 (DAOM). N. B.; Stillwell 87394 (DAOM). Nfld.; Stillwell 46768 (DAOM). Ont.; M. Nobles 46790 (DAOM), H. S. Jackson 50124 (DAOM), 8060 (DAOM). U.S.A.: Idaho; O. K. Miller 2850 (BFDL), 2856 (BFDL), 2901 (BFDL). A. H. Smith 54578 (MICH), 54842 (MICH), 55296 (MICH). Oregon; A. H. Smith 18133 (MICH), 55403 (MICH). Europe: Sweden; S. Lundell, Fungi Exsiccati Suecici 9. (BPI). Norway; J. Stordal 65000 (DAOM).

4. *Panellus stipticus* (Bull. ex Fr.) Karst. Figs. 16-21, 29, 30, 34.
Bidr. Kann. Finl. Nat. Folk. 32: XIV. 96. 1879.

Agaricus stipticus Bull. ex Fr., Syst. Mycol. 1: 188. 1821.
Panus stipticus (Bull. ex Fr.) Fr., Epicr. Mycol. 399. 1838.

Pileus (5-)12-32 mm long, 12-15(-25) mm wide, convex to plano-convex, crenulate margin in age, dry areolate, woolly-pubescent, sometimes with several concentric ridges or zones, ochraceous buff, "pale ochraceous buff" to "light ochraceous buff," various shades of tan or brown when dried. Lamellae close, narrow, often forked, "ochraceous-buff" to "ochraceous salmon" even "tawny olive" in age. Stipe 6-12 mm long, 3-8 mm wide, usually eccentric, often lateral, minutely fibrillose, dull white, constricted somewhat just at base. Taste slightly acrid, perhaps somewhat astringent. Odor not distinctive.

Spores (3.0-)3.5-4.6 × 1.2-2.2 μ, elliptical to somewhat allantoid, with yellow contents and amyloid (blue) walls in Melzer's solution. Basidia 15-20 × 2.5-3.5 μ, narrowly clavate, 4-spored. Cheilocystidia 17-45 × 3.5-6.0 μ, narrowly clavate, cylindric, clavate-rostrate, fusiform to bifurcate, thin-walled, hyaline, abundant, protruding 1/2 total length or more (Fig. 30). Pleurocystidia 19-40 × 3.0-4.5 μ, fusiform, narrowly clavate, to bifurcate at apex, thin-walled, hyaline, scattered or in a dense cluster, occasionally protruding up to 1/2 total length. Cuticle of pileus a tangle of thick- and thin-walled, clamped hyphae 1.2-6.0 μ diam. (Fig. 29) with scattered inconspicuous pileocystidia 40-55 × 3.5-5.5 μ, cylindric to cylindric-capitate, thin-walled, often with a basal clamp, yellowish in Melzer's solution, hyaline in KOH and with scattered amorphous, embedded, dingy brown, incrusted material on the wall. Trama of pileus obscurely duplex with a layer of upright hyphae blending into a lower layer of interwoven hyphae (2.5-8.0 μ diam.), thin- and thick-walled, with clamp connections, light ochraceous to dingy yellowish in Melzer's solution, light yellowish to nearly hyaline in KOH. Trama of the lamellae of interwoven hyphae, mostly thick-walled, similar in all aspects to the lower pileus trama.

Habit and habitat.—Usually in tightly packed imbricate clusters as a saprophyte on the sides of logs, limbs, and stumps of hardwoods. Noted on *Quercus, Acer, Alnus, Betula* and on wood in service, particularly structural timbers. Fruiting in the fall in September, October, and November in Europe and North America.

Observations.—The brown pileus, luminescent lamellae, and constant presence of a short lateral stipe, combined with abundant, protruding cheilocystidia (Fig. 30) and the unique woolly-pubescent cuticle (Fig. 29) clearly separate *P. stipticus* from all other species in the genus. The amyloid (blue) spore, thick-walled hyphae of the trama of the lamellae and pileus, ability to revive when moistened, and lignicolous habitat, combined with the smooth (non-serrate) edges of the lamellae were used as central characters in erecting *Panellus* as a genus in the Tricholomataceae. It is spelled "*P. stypticus*" by many authors and is named for its styptic or astringent properties.

Buller (1924) investigated the luminescence of *P. stipticus* and found that the lamellae of the North American fruiting bodies are luminescent but the phenomenon cannot be observed in European specimens. Twelve hours exposure of the gills to film in complete darkness yielded negative results with

Fig. 32. *P. patellaris* (× 2) Photo by J. Lindsay.
Fig. 33. *P. serotinus* (× ½) Photo by A. H. Smith.
Fig. 34. *P. stipticus* (× ½) Photo by A. H. Smith.

European material eliminating the possibility of very low levels of luminescence. Mycelium was examined by Buller (1924) and again luminescence of the vegetative cells could only be demonstrated in North American material. He compared spores and other morphological features of the fruiting bodies on both continents but no additional constant differences could be found. He concluded that two physiological races could be discerned and that both were variants of *P. stipticus*. The luminescence is usually visible after several minutes in a dark room and best observed in temperatures from 10 to 25°C.

Material examined.–U.S.A.: Idaho; O. K. Miller 2937 (BFDL). Louisiana; A. Laska 2639 (BFDL). Maryland; O. K. Miller 3668 (BFDL), 5100 (BFDL), 5102 (BFDL), 7119 (BFDL). Michigan; O. K. Miller 43 (BFDL), 1308 (BFDL), A. H. Smith 75145 (MICH). New York; O. K. Miller 3550 (BFDL), R. L. Gilbertson 6828 (BFDL). Washington D. C.; O. K. Miller 4949 (BFDL).

5. *Panellus ringens* (Fr.) Romagnesi. Figs. 22-26, 36.
Bull. Soc. Mycol. Fr. 61: 38. 1945.

Lentinus ringens Fr. Epicr. Syst. Mycol. 396. 1836-38.
Panus salicinus Peck. N. Y. State Mus. Rep. 24: 77. 1872.
Panus ringens Fr. Hymen. Europe. 490. 1874.

Pileus (5-) 10-30 mm in diam., sessile, margin even to somewhat crenate, sometimes irregularly striate (see Fig. 36), light purple to purple drab or lilac colored with vinaceous tints ("purple-drab," "dark purple drab") fading in age sometimes to "vinaceous fawn" with a conspicuous pallid pubescence which is dense over the lateral attachment of the cap (Fig. 36) to the substrate; dried material is "vinaceous gray" to "lilac gray" at point of attachment. Lamellae radiating from the point of attachment, fawn to pink ("fawn color," "vinaceous-fawn" to "vinaceous-pink") often fading in age, reddish-brown when dried ("mikado brown" to "verona brown").

Spores (4.0-) 5.0-7.0 × 1.2-2.0 μ, oblong to allantoid, amyloid (blue in Melzer's solution), hyaline in KOH, often hard to find. Basidia 17-27 × (2.5-)3.5-6.3 μ, narrowly clavate, 4-spored. Pleurocystidia not found. Cheilocystidia 24-38 × 4.2-5.5 μ, clavate, cylindric, fusiform, thin-walled, hyaline in Melzer's solution and KOH, infrequent. Cuticle of pileus of single, tangled, or fasciculate thin- and thick-walled clamped hyphae 2.5-5.0 μ diam., hyaline to light yellowish in Melzer's solution and KOH. Trama of pileus and lamellae of interwoven, thick-walled and infrequent thin-walled hyphae 3.5-7.0 μ diam., light yellowish in Melzer's, hyaline in KOH. Subhymenium a thin layer of tightly interwoven hyphae 1.0-2.5 μ diam.

Habit, habitat, and distribution.–Several to gregarious, often lining the sides of sticks and limbs on the ground, sometimes nearly imbricate. Recorded on species of *Alnus, Betula*, and *Salix* in Europe and North America but in Europe it is also occasionally found on conifers. It is widespread in North America, from Maine to Idaho and north into Canada. Fruiting in late summer and fall but the persistent sporophores have been collected throughout the winter.

Observations.–*P. ringens* is closely related to *P. violaceofulvus* but has smaller spores, smaller basidia, lacks a cellular hymenopodium, and does not

Fig. 35. *P. mitis* (× 1) Photo by A. H. Smith.
Fig. 36. *P. ringens* (× 6) Photo by O. K. Miller.

develop a venose hymenium between the lamellae. However, both species are purple to violet or violet tinted. *P. ringens* has been mistakenly identified as *P. violaceofulvus* (Batsch ex Fr.) Sing. by American authors and is discussed further by Miller (1967). The two collections cited by Coker (1944) were examined and both have the short spores and other characters of *P. ringens.*

Material examined.–Europe: Finland; Karsten Jan. 2, 1866 (NY). Italy; G. Bresadola, March 13, 1896 (BPI). Sweden; Bruun and Lundell, Fungi Exsiccati Suecici, 231 (BPI), A. Melderis 66411 (DAOM). Switzerland; Quélet 1890 (NY). North America: Canada. Ontario; J. Dearness (Peck 203) (MICH), J. W. Groves 17446 (MICH), J. Dearness 203 (NY), Feb. 1890 (NY), Elles & Everhart 2503 (NY), R. F. Cain 21551 (NY), 80577 (DAOM), A. H. Smith 80576 (DAOM). North America: U.S.A.: Colorado; Seaver & Bethel Aug. 30, 1910 (NY). Idaho; O. K. Miller 2908 (BFDL), 2933 (BFDL), 2937 (BFDL), 4893 (BFDL), J. R. Weir 5541 (NY), J. R. Weir & A. S. Rhodes 16145 (BPI), 16146 (BPI). Maine; Murrill 2017 (NY), 2026 (NY). Maryland; O. K. Miller & J. Lindsay OKM 5026 (BFDL). New York. C. H. Peck, Center, New York (type of *Panus salicinus* Pk.) (NYS), O. K. Miller 3594 (BFDL), C. L. Shear 108 (NY). Pennsylvania; Herbst (NY).

6. *Panellus violaceofulvus* (Batsch ex Fr.) Sing.
Ann. Mycol. 34: 335. 1936.

Pileus 3-15 mm diam., sessile or with a short rudimentary stipe; margin even to slightly wavy, inrolled at first, dry, brown tinted violet, or darker violet-brown with a conspicuous white, woolly pubescence. Lamellae subdistant, sometimes venose, pale violet to brownish in age.

Spores 6.5-10.0 × 2.2-3.5 μ, cylindric to somewhat allantoid, amyloid. Basidia 25-35 × 4.5-6.0 μ, clavate, 4-spored. Cystidia, none seen. Cuticle of pileus of interwoven or loosely fasciculate, thick-walled, clamped hyphae 3.5-6.0 diam., light yellow brown in Melzer's, hyaline in KOH. Trama of pileus and lamellae of interwoven thick-walled, clamped hyphae 3.5-10.0 μ diam., light yellowish in Melzer's, hyaline in KOH. Subhymenium a cellular hymenopodium, particularly evident near gill attachment to pileus.

Habit, habitat, and distribution.–Several to many, often somewhat imbricate, on small limbs and logs. The only collection examined from North America was on balsam fir (*Abies balsamea*) from Anticosti Island in eastern Quebec, Canada. In Europe it has been reported on silver fir (*Abies alba* or *A. pectinata* of some authors) and other conifers, usually at high elevations in the Alps.

Observations.–Collections identified as *Panus, Resupinatus,* and *Panellus violaceofulvus* have been examined from a number of herbaria (MICH, QFB, BPI, BFDL, DAOM and NY). All North American collections which I have studied with one exception discussed above are *Panellus ringens* (Fr.) Sing. and are easily identified by the short spores, absence of a cellular hymenopodium, short basidia, and their occurrence on species of hardwood, particularly *Alnus, Salix,* and *Betula.* It is quite likely that *P. violaceofulvus* will be encountered frequently in the northern boreal forests.

Material examined.–Canada: Quebec; G. B. Ouellette 5083 (QFB). Europe: Austria; Magmus (NY), Italy; Bresadola 1896 (NY). Switzerland; 405. Les Champ. du Jura et des Vosges (NY).

EXCLUDED SPECIES

The following list deals only with species found in North America which have been referred to *Panellus.*

Panellus dealbatus (Berk.) Murrill. N. Am. Flora 9: 245-246. 1915.
=*Asterotus dealbatus* (Berk.) Sing. Mycologia 35: 161. 1943.

Panellus eugrammus (Mont.) Murrill. N. Am. Flora 9: 245. 1915.
=*Nothopanus eugrammus* (Mont.) Sing. Mycologia 36: 364. 1944.

Panellus haematopus (Berk.) Murrill. N. Am. Flora 9: 246. 1915.
=*Panus suavissimus* (Fr.) Sing.

Panellus mirabilis Singer. Mycologia 47: 770-771. 1955.
=*Mycena mirabilis* (Sing.) O. K. Miller comb. nov.

The type specimens of this minute fungus have central or slightly eccentric stipes which recurve very sharply from the host. It does not revive as the species of *Panellus* do, and the hyphae of the trama of the lamellae are thin-walled. In addition, the spores are very weakly amyloid, elliptical, pointed at one end, 6.0-9.5 × 2.5-4.0 μ, and not the usual allantoid to narrowly elliptical spores of *Panellus.* The cheilocystidia are of two types: (A) Clavate end-cells with dingy yellow contents 20-30 × 8-10 μ, thin-walled, often embedded or protruding slightly; (B) Narrowly clavate to cylindric cells with branched projections 18-35 × 2-4 μ, thin-walled, hyaline. Pleurocystidia 21-35 × 5-7 μ, clavate to fusiform, with a short blunt tapered apex, thin-walled, and hyaline. In addition, the subcutis and trama of the pileus is deep red in Melzer's solution. The above combination of characters is found only in the genus *Mycena, Eumycena* in the section *Corticolae.* The cheilocystidia resemble those of *Mycena corticalis* A. H. Smith, while the spores are very much like those of *Mycena madronicola* A. H. Smith (Smith, 1947, Fig. 3).

Panellus vulpinus (Sow.) Murrill. N. Am. Flora 9: 246. 1915.
=*Lentinellus vulpinus* (Sow. ex Fr.) Kühn et R. Maire, Bull. Soc. Myc. Fr. 61: 44. 1946.

SUMMARY

Six species of *Panellus* are described from North America. A number of new characters have been found or used to clearly delimit species using material in either the fresh or dried condition. New ecological data, hosts, and wider distributions have been presented for many species. A key to the species is provided along with camera lucida drawings and photomicrographs to illustrate the important characters. Macrophotographs of five species are included.

ACKNOWLEDGMENTS

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A NEW *CLITOCYBE* FROM MICHIGAN

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One studying the fleshy fungi soon becomes almost immune to surprises, but we must confess that a fungus collected several times in the spring of 1969 in a rose house in Mt. Clemens, Michigan, shocked us both. The basidiocarps of the species were very much like those of the *Clitocybe irina* group (Bigelow & Smith, Brittonia 21: 144-177. 1969), but the color of the spore deposit was dark vinaceous brown. A survey of the literature did not reveal the presence of such a species in any region of the world. Hence we describe the fungus here as new and take pleasure in dedicating it to Prof. E. S. Beneke of Michigan State University, who first recognized it as a mushroom extraordinary.

Clitocybe benekei sp. nov. Figs. 1-3.

Pileus 8-15 cm latus, convexus, margine incurvatus ad crenatus, superficies glaber, humidus, hygrophanus, pallide incarnato-bubalinus tum sordido-pallidus. Caro albidus. Odor et sapor ingratus. Lamellae adnatae vel breviter decurrentes, confertae, latae, pallide tum vinaceo-brunneae. Stipes 6-12 cm longus, apice 1-3 cm crassus, aequalis vel basi bulbosus, solidus, fibrosus, superficies asper, sordido-pallidus. Sporae 5.5-7 × 4.5-5 μ, verrucosae, in cumulo vinaceo-brunneae. Typum legit E. S. Beneke (A. H. Smith no. 77176), Mt. Clemens, Mich. (Holotypus MICH; isotypus MSC).

Fig. 1. *Clitocybe benekei*, slightly reduced. Type collection.

Pileus 8-15 cm broad, broadly convex with an incurved margin, becoming wavy to crenate or scalloped in age, surface glabrous, moist, hygrophanous, color a watery pale pinkish buff to cartridge buff when moist, fading to dingy pallid, in age often brownish pallid from spores. Context white, not changing overnight after being broken or bruised, floccose; odor and taste disagreeable. $FeSO_4$—no reaction.

Lamellae adnate to short decurrent, seceding but tearing the context when separating, close, broad, pallid but finally becoming "wood brown," not discoloring overnight where bruised, edges even, thin.

Stipe 6-12 cm long, 1-3 cm thick at apex, equal or the base bulbous, solid, fibrous, whitish within, unchanging or merely slightly dingy from bruising; surface uneven, pallid like the faded pileus. Veil absent.

Spores 5.5-7 × 4.5-5 μ, elliptic, distinctly verrucose (warts up to 0.5 μ high), hyaline in KOH, in Melzer's solution fresh spores showing rare amyloid particles within, particles not evident in dried spores revived in Melzer's but the ornamentation appearing weakly amyloid in some, deposit "wood brown" to "army brown."

Basidia 18-33 × 6.5-9.5 μ, 4-spored. Cystidia not differentiated. Pileus with a surface layer of somewhat gelatinous hyphae in KOH as viewed under the microscope, the hyphae cylindric and 2-5 μ wide; pileus tramal hyphae cylindric to somewhat inflated, 6.5-13 μ wide, cells often short. Hymenophoral trama of hyphae parallel to subparallel, cylindric to somewhat inflated, 2-14 μ wide. Clamp connections present.

Fig. 2. *Clitocybe benekei,* × 3/4. Type collection.

Cespitose on mulch in rose beds in greenhouses near Mt. Clemens, Macomb County, Michigan, March and April, 1965; type *Smith 77176* (MICH), comm. by Dr. E. S. Beneke.

The type collection consisted of a market basket full of basidiocarps and it is from these that our description is drawn and the photographs taken. In general aspect *Clitocybe benekei* appears to belong to the group of species centered around *Clitocybe irina,* but the dark-colored spore deposit and relatively coarse spore ornamentation at once distinguish it. The habitat and manner of fruiting are typical for members of section *Verruculosae* of *Clitocybe* such as *C. subconnexa,* the type of the section. Members of this section are often found in quantity fruiting on mulch or on compost heaps out of doors.

The unusual features are the dark vinaceous-brown spore deposit which becomes gray-brown as it air dries, and the slight amyloid reaction of the spore ornamentation. When fresh the spore deposit has the color of that of some species of *Agaricus.* The rare amyloid particles found within freshly deposited spores when mounted in Melzer's solution have not been reported previously for any taxon in *Clitocybe,* but we do not regard them as an aid in identifying the species because they are so rare and easily overlooked. The obscure amyloid reaciton of the ornamentation on the spore wall appears to be more noteworthy at least as far as postulating relationships of the section to other groups in the Tricholomataceae is concerned. It may very well be true that the difference between amyloid and non-amyloid spores is not of major significance in establishing phylogenetic lines.

Fig. 3. *Clitocybe benekei,* × 3/8. Type Collection.

CHARLES HENRY SWIFT–1881-1966[1]

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With the death of Charles H. Swift on November 17, 1966, from a ruptured abdominal aneurysm, the world lost one of its last naturalists and scholars reared in the tradition of the nineteenth century; his many friends lost one of their most charming companions.

Charles Swift was born in the bluegrass country of Kentucky, August 17, 1881, the son of extraordinary parents. His father's family was of English (Lincolnshire) stock; his grandfather was a teacher and city librarian of Lexington, Kentucky, renowned for his encyclopedic knowledge. Charlie's father, William Swift (1834-1914), was a perpetual student and teacher with degrees in law (LL.B., Lexington) and medicine (M.D., Lexington); he become professor of all the sciences in Christian College at Millersburg, Kentucky, occupying, as someone has said, not a chair but a settee! Charlie's instruction in science began as a small child when his father taught him the lore of trees, flowers, and birds and inspired his son with a love of knowledge. The Louisville public schools provided the formal education culminating in a sort of collegiate high school affiliation with the old University of Louisville from which, on graduation, Charlie was awarded the A.B. degree.

The Swift family had the Chautauqua habit in the nineties, from which followed at least two important consequences. The first of these was acquaintance with William Rainey Harper and a decision to move to Chicago so that the children could attend the new University of Chicago. The idea of moving to Chicago and the decision to do so is ascribed to Charlie's mother, Helen Mar Kelly Swift (1840-1929), a strong-minded woman of Scotch-Irish ancestry who was determined to obtain the best possible educational opportunities for her son Charlie and her daughter Verger Rebecca Swift. The mother exerted a profound influence on both of her children until the time of her death at the age of 88 years.

Charlie matriculated at the University of Chicago in 1899 and received an A.B. in History with the minor in Latin and Greek in 1903. His early interest in nature then led him to the sciences; he qualified for and in 1906 received a third bachelor's degree, a B.S. in Botany and in Anatomy. The interest in anatomy led him to the broad field of medicine and resulted in 1910 in an M.D. degree from Rush Medical College. Dr. Swift never practised medicine but he derived great satisfaction from the fact that he was a qualified physician and proudly renewed his license annually in order to be able to prescribe for his friends. Upon his graduation from medical school Dr. Swift became an

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[1]Expanded version of a notice which appeared in the Anatomical Record 165: 268-269 (1969); used by permission of the Wistar Institute Press.

Instructor in Anatomy at the University of Chicago; in 1913 he was awarded the Ph.D. degree with anatomy as the principal subject and botany secondary. In 1918 he was promoted to Assistant Professor. Advancement to Associate Professorship came in 1929 and retirement as Associate Professor Emeritus in 1946.

Dr. Swift began his research during his Fellowship in Anatomy in 1908-1909 and continued it after his appointment as Instructor. His papers on Primordial Germ Cells in the Chick and the Yolk Nucleus of Balbiani were published in the *American Journal of Anatomy* in 1914, 1915, and 1916. Appreciation was immediate and general; within a year this work was famous in Europe and America! Recognized at the time as a classic study, it is still so rated more than 50 years after its publication.[2,3]

During World War I, Dr. Swift's heavy teaching schedule interrupted his research. He abhorred the lecture system and even with the relatively large classes, preferred, as I remember him in 1917, to spend his time at the dissecting tables, sitting on a stool, discoursing on anatomy. His photographic memory enabled him to quote at length from Gray's Anatomy, Cunningham, Spalteholtz, or any other treatise of importance. In the early 1920's Dr. Swift organized the first course in the University on the History of Medicine. It was an immediate success and was continued until his retirement in 1946.

Dr. Swift's knowledge encompassed almost all significant subjects and some not so significant, such as the railroad timetables of the United States and Canada. He is known to have worn out one Encyclopedia Britannica and started on a second! His memory for faces and names was excellent; he possessed the gift of instant recall so that, meeting a former student anywhere, he would recognize him immediately and give his name and class. The mutual affection between students and teacher was evidenced by the appreciative remarks made by his former students at his retirement in 1946 and again after his death in 1966.

Two fascinating questions arise. Why did Dr. Swift fail to continue his investigative career and why did he fail advancement to full professorship? Some of his friends have thought the explanation to be that the teaching and administrative responsibilities of the war years drew him away from research; this is not an adequate answer. Charlie possessed abundant intellectual curiosity, vigor, and ability. His wide-ranging mind was filled with his studies of history, botany, ornithology, and science; everything interested him. Pressure for research surrounded him. In the history of the world, at least in modern times, there has never been a department of anatomy with so many giants as at Chicago in the first third or so of this century:[2] Robert Russell Bensley (1867-1956), Chairman of the Department from 1905 to 1933, has been ranked as the greatest of the American anatomists.[4] George W. Bartelmez

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[2]William Bloom, personal communication.

[3]Lincoln V. Domm, personal communication; Basil C. H. Harvey, "After Forty-Seven Years: Indian Summer," Univ. Chicago Mag. December 1946, pp. 5-6.

[4]Basil C. H. Harvey, remarks at the memorial service for R. R. Bensley, November 13, 1956; Howard Wakefield, personal communication.

Fig. 1. Charles Henry Swift (1881-1966). Photograph by Joseph Merante.

(1885-1967) was one of the world's leading investigators of human embryology;[5] C. Judson Herrick (1868-1960), a recognized genius, devoted his life to the study of the brain and nervous system, published at least 13 books and 200 scientific scholarly papers, and remained active until his death at the age of 92 years; A. A. Maximow (1874-1928), even before his migration from Russia to Chicago in 1922, was described by Florence Sabin as the greatest histologist in the world.[2] Basil C. H. Harvey (1875-1958) in the years from 1901 to 1917 rose rapidly through the five faculty ranks from Assistant to Professor before being called into military service. Upon his return Dr. Harvey resumed his research with Dr. Bensley and his beloved teaching. The University soon induced him to accept the position of Dean of Medical Students, an assignment he filled with distinction and yet found time to write on topics in anatomy and medical education.

Dr. Swift devoted himself to the teaching of gross anatomy and yet balked at investigation and writing. Why? It is tempting to suggest that he reacted against the tremendous pressure for research, as did most of his students. Charlie himself alleged in later years that he had failed to continue his early superb studies because of his clumsiness with the microtome and the punishment he inflicted on his own fingers and thumbs. Neither he nor the department could afford the luxury of a technician and so the investigation ceased. This explanation does not account for his failure to carry out other types of creative work or to write on the history of medicine he knew so well. Charlie was not a man to yield to pressure from any source. He knew nothing of grantmanship, of the "publish or perish" philosophy of the modern university, although in a sense he was an early victim. He loved knowledge for its own sake, as something to be relished and savored, as some people prize a fine wine; he would not seek knowledge for money or promotion, but only for enjoyment. He delighted in every new fact he learned. I can picture in my mind the merry way he would have ridiculed and rejected any suggestion that he prostitute his talents for forty pieces of silver! And yet to many of the academic idealists in science in both the past and present generations, no man merits full professorship without continued activity in research. Dr. Swift never complained, even to his closest associates. Nevertheless, it is distressing to think of the number of lesser men to whom the accolade of full professorship has been given!

Reference was made earlier to the Chautauqua habit of the Swift family in the nineties. This led to participation in a similar colony at Bay View, Michigan, established under the auspices of a group of Methodists. The Swift family bought a cottage; Charlie took an active role in the Bay View enterprise and returned every summer for the rest of his life. It was there that he met Juliana Streid of Washington, Illinois, the sister of Charlie's close friend and classmate, Joseph Streid, who had died in his senior year at Rush. Charlie and Juliana were married in 1920; Juliana survives him.

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[5]George W. Corner, "George W. Bartelmez," Anat. Record 161: 533-534. 1968.

Charlie's father had been an artillery officer in the Confederate Army serving with Bragg, Morgan the Raider, and Breckenridge. As a boy and as a youth, Charlie attended the annual reunions with his father and listened with rapt attention to the tales of the old soldiers. From this grew an avid interest in the history of the conflict. He read every book he could find on the War and its leaders; with his marvelous memory he could discourse at length. I think his favorite work was Douglas Southall Freeman's three-volume *Lee's Lieutenants - A Study in Command* (Scribners, 1943), given him by Juliana in 1942 and graciously passed on by her to me after his death. Charlie is said to have been an especial authority on the Battle of Gettysburg, but he knew the disposition of troops in every battle and the comments of the generals afterwards. His appraisals of the War, the armies, the leaders, and the issues at stake, were all remarkably objective. Dr. Swift was almost equally familiar with the other great wars of history. One day I casually asked him what had happened to Alexander the Great in India; a look of incredulity came over his face and he proceeded to give me a detailed account of Alexander's last campaign.

Dr. Swift's keen interest in ornithology continued throughout his life. He kept a diary dating the first appearance of the various birds each spring as they came through Chicago. Frequent expeditions were made almost until the last to the sand dunes and other areas favored by the bird watchers. The numbers of birds he would identify from his apartment window amazed his friends. Whether he talked of a bird, a tree, a bush, or a flower, Charlie could expound on its common and scientific names, its habits and characteristics.

Economics and politics were of much less interest to him than were history and science, but at times in a discussion he would begin with Adam Bede or before, and end by giving his views of contemporary problems. A Democrat born and raised, he learned to vote the Republican ticket and laughingly remarked that, were his father to know that he had done so, he would turn over in his grave!

Active, alert, energetic until the day of his death at the age of 85, Charlie Swift will be remembered by his friends, colleagues, and students for his warm friendship, his encyclopedic knowledge, his gay wit, his keen sense of humor, and his rare charm. He was large of heart, mind, stature, and talent. We shall not see his like again.

CHARLES H. SWIFT'S BOTANICAL WORK IN MICHIGAN[6]

As soon as he came to the University of Chicago in 1899, Charles Swift associated in the botany department with John Merle Coulter and Henry Chandler Cowles. He immediately started learning the Chicago area plants. Whether Coulter, who had been director of the Bay View Summer School from 1893 to 1896, helped to influence the Swifts in their decision to summer at Bay View, Michigan, I do not know. At any rate, from his first summer at Bay View, in 1899, until the end, Charles Swift was devoted to the

[6]Appended by Edward G. Voss.

14 Cinna latifolia (Trev) Griseb.
Deep Woods. R.C. F.

Danthonia spicata. (L) Beauv.
C in dry places. F & S.

Spartina Michauxiana. Hitchc
R. H.S. Wet spot of little Traverse
at Ramona Park. F & S

Phragmites communis. Trin
C. S
Eragrostis megastachya (Koeler) Link
R.R. — In waste grounds F

Dactylis glomerata. L
C. F & S
Cynosurus cristatus L
Wet Banks Br 1894 F
V.R.

Poa compressa L 2
C F & S
C. Poa annua L 1
Com. in cultivated grounds F

15

Poa pratensis. L 4
VC.
Poa alsodes Gray 5
R.C. Thicket &c 7.

Glyceria nervata. (Willd) Trin
VC. Low places. Very variable.
Glyceria septentrionalis Hitchc
Near B.L. 1916 C.H.7. R.R.

Festuca ovina. L 3
VC. 7 & S. 5
Festuca nutans Sprengel
B.V. 1894 F. C.

Festuca elatior. L 4
C. Roadsides. F & S. 1
Festuca hubra L
E of Petoskey 1895 F. R.
Festuca Rubra subvillosa Hackel & Koch. 2
B.L. 1916 Swift

Bromus tectorum. L 2
V.R. One situation along G.R. and O
right of way near B.V. F and Shrader
Bromus secalinus L 1
C. F.

Fig. 2. Two pages from the original Fallass and Swift manuscript list of the Emmet County flora. The larger writing is Swift's. (Reprinted from Asa Gray Bull. N. S. 3: 91. 1955)

plants of that area. On July 1, 1903, he met Charles W. Fallass (1854-1942),[7] an ardent botanist by avocation, who had moved to Petoskey in 1898 and who had summered at Bay View since 1887. Both Fallass and Swift had been botanizing that day west of Harbor Springs, and when they met in the field, each with a vasculum over his shoulder, sharing their joy at having found the rare *Orchis rotundifolia,* there began an acquaintance which lasted for forty years.

The Fallass and Swift team explored together, at first by train or on foot and later by auto, many parts of Emmet County and the Jack pine plains of Cheboygan County. About 1917 Swift suggested that a list of the vascular plants of this region be prepared. He drew up an annotated list of about 600 species and Fallass added another 200. Two pages from the original list (presented to me in 1965 by Dr. Swift) are reproduced in Fig. 2. A few copies of the list were made and distributed, and although it was never published it became cited in various works on the flora of Michigan. Dr. Swift's prime interest was in identification; once he learned a plant and noted it in his manual, he generally preserved no specimen. Mr. Fallass was the collector, and his herbarium, now at Albion College (Albion, Michigan), includes almost all of the few specimens actually collected by Swift. Two exceptions are the types of some unusual forms of the purple-fringed orchid, *Habenaria psycodes,* found by Dr. Swift at Round Lake near Bay View in July of 1913. These were described, with full credit to Swift, by Mary M. Bryan (Ann. Missouri Bot. Gard. 4: 37-42. 1917) as var. *varians* (lacking the central lobe of the lip) and var. *ecalcarata* (lacking both spur and fringe on the lip); these specimens are in the herbarium of the Missouri Botanical Garden.

From the time of my first correspondence with him in 1954 until my last visit with him and Mrs. Swift at Bay View in 1965, it was clear to me not only that Dr. Swift was a botanist intensely interested in the same local flora as I—and one who had been actively studying it years before the nearby University of Michigan Biological Station was founded in 1909!—but also that he possessed those qualities of scholarship and charm which are so well portrayed in the preceding sketch.

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[7]See Edward G. Voss, "Charles W. Fallass (1854-1942), a Pioneer Michigan Botanist," Asa Gray Bull. N. S. 3: 77-96. 1955.

TYPE SPECIMENS OF FLOWERING PLANTS DESCRIBED FROM LONG'S EXPEDITION TO THE SOURCE OF THE ST. PETER'S RIVER IN 1823[1]

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In the herbarium of the Academy of Natural Sciences of Philadelphia is a small collection of plants that once was a part of the large herbarium of the Rev. Lewis David von Schweinitz. These specimens are the basis for Schweinitz's catalogue of plants collected in the northwestern territory by Mr. Thomas Say on Major Stephen H. Long's Expedition in 1823 (Schweinitz, 1824). Schweinitz enumerated 130 taxa including 11 new species and five new varieties of flowering plants. The present paper summarizes the historical background for these collections, and enumerates the existing type specimens with their limited data.

THE EXPEDITION

As recorded by Keating (1824), the Honorable J. C. Calhoun, Secretary of War, ordered an expedition to the source of the St. Peter's River (Minnesota River) in 1823 under the command of Stephen H. Long, Major, United States Topographical Engineers. The United States government wished to assemble more information for a topographical description of the region, to ascertain the latitude and longitude of all the remarkable points, and to examine and describe its animal, vegetable, and mineral productions. The country to be explored was that bounded by the Missouri and Mississippi Rivers and the northern boundary of the United States. The exploring party left Philadelphia on 30 April 1823, and traveled westward across Pennsylvania and Maryland to Wheeling, then through central Ohio to Fort Wayne and Chicago. From Chicago the expedition proceeded across Wisconsin Territory to Prairie du Chien, up the Mississippi River to Fort St. Anthony, then to the source of the St. Peter's River, down the Red River past the International Boundary and on to Winnepeek Lake [Lake Winnipeg, Manitoba]. Turning eastward the exploring party went via Lake of the Woods, Rainy Lake, Falls of Kakabeka, the north shore of Lake Superior, down through Lake Huron, across Lake Erie, and homeward–reaching Philadelphia 26 October 1823. A detailed map of the route traveled appears in Keating (1824), and a more general map is in Barber (1928) which was later reprinted in Weiss and Ziegler (1931, p. 189).

Dr. Edwin James, botanist of a previous expedition under the command of Major Long to the Rocky Mountains in 1819-20, was appointed botanist, geologist, and physician to the 1823 expedition. Because he failed to receive his instructions for making connections with the party at Wheeling or Colum-

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[1]Contribution from the Botany Program (Paper No. 764) and the Herbarium of The Ohio State University.

bus, he waited for them at Pittsburgh while the party was passing through Wheeling. By the time James received the communication he could not catch the party. Accordingly, Thomas Say, zoologist and antiquary on the expedition, undertook to collect such plants as might appear to him interesting. According to Brendel (1879) several boxes containing botanical collections dispatched during the expedition were lost. Brendel's undocumented statement has not been commented upon or documented by later botanical historians. However, the plants that were brought back were available for study. Thomas Nuttall, perhaps the most noted naturalist, explorer, and botanist of the time, applied successfully to Major Long for the opportunity of preparing the botanical report from the dried specimens. As discussed by Graustein (1967, p. 195), when it came time for Nuttall to sail for England, in about mid-November of 1823, he had merely begun the work on the plants. He returned the materials, with the intent of working on them upon his return in the spring. When no word had been heard from Nuttall by the first of the following July, Keating arranged for Schweinitz to prepare the plant list and descriptions. Within about four months, Schweinitz organized the plants, and the complete report was published before the end of 1824 (Keating, 1824).

SCHWEINITZ'S *CATALOGUE*

Two published versions of Schweinitz's *Catalogue* appeared, the first printed in Philadelphia in 1824 and the second printed in London in 1825. Both editions contain exactly the same botanical information. However, the type was reset and the pagination changed in the second printing. The names of the new taxa date from the 1824 edition published as Section II in the Appendix with pages numbered consecutively from Keating's *Narrative.* In the 1825 printing, the Appendix begins with page one.

In the introduction to the *Catalogue,* Schweinitz points out that Nuttall, who had begun the identifications and the writing of the text, had not returned from Europe in time to complete the work. Schweinitz reveals that he undertook the task with "great diffidence and sincere regret." Although the published introduction differs from that in Schweinitz's original manuscript copy in the library of the Academy of Natural Sciences, both versions convey essentially the same information.

One-hundred thirty plant taxa are listed. Schweinitz relied on Pursh's *Flora* ("1814" [1813]) and Nuttall's *Genera* (1818), as his primary sources for the identification of the plants. References and page numbers to these floras usually accompany the names of the plants. Locality information is lacking for many of the species. However, in certain cases, if Schweinitz knew the species, he commented on its occurrence or abundance elsewhere, such as in the eastern or southeastern United States or in Europe—geographical areas where he had had previous experience with the flora. The localities mentioned especially for the northwest were places where plants were obtained along the route between Fort Wayne and the north shore of Lake Superior. Those localities most often cited were Prairies of the St. Peter and Red Rivers, Lake of the Woods, Falls of Kakabeka, and the north shore of Lake Superior.

According to the introduction in Schweinitz's *Catalogue* (1824), and as mentioned by Upham (1884) and Graustein (1967), the first five plants were named by Nuttall. Four of the first five entries bear names given to them by Nuttall. According to Schweinitz number four, "*Cyperus *alterniflorus,*" was "labelled *Cyperus* by Mr. Nuttall," but Schweinitz states that he himself prepared the description and I assume he also provided the epithet. Rodgers (1942, footnote, p. 53) believed that Torrey aided Schweinitz in the preparation of the *Catalogue,* but there is no indication in the *Catalogue* itself or in the published correspondence between Schweinitz and Torrey (Shear & Stevens, 1921), that Torrey helped Schweinitz in organizing or naming the plants from Long's 1823 expedition.

In the published version of the *Catalogue,* each plant (taxon) bears a number. Some of the type specimens and other specimens in the collection also have numbers on their labels. Each plant specimen number is one digit lower than the published number in the *Catalogue,* with one type, specimen number 5, *Eriophorum angustifolium* β **megastachyon,* being an exception. This discrepancy in numbering can be explained after comparing the manuscript version of the *Catalogue* with the published version. The former does not list *Limnetis glabra,* but it was inserted in the latter as number 6. Those taxa listed after number 6, therefore, have numbers one digit higher than the numbers on the specimen labels. Nuttall's new *Eriophorum,* specimen number 5, was unaffected by this insertion. In the manuscript version of Schweinitz's *Catalogue* the taxa are not numbered and Nuttall's description of *Eriophorum angustifolium* β **megastachyon* is missing, both items evidently having been added at the time of printing.

THE TYPE SPECIMENS

After examining some of the type specimens, I realized that certain past and recent monographers were either unaware of these species and their type specimens at the Academy or had overlooked these specimens in their studies even after annotating them. To cite one example, M. L. Fernald annotated the type specimen of *Eriophorum angustifolium* β **megastachyon* as *Eriophorum viridi-carinatum* (Engelm.) Fernald, but did not mark it as a type, did not treat it in synonymy, or even mention it in his treatment of the genus for North America (Rhodora 7: 81-92. 1905).

In January of 1969 while at the Academy Herbarium, I undertook to locate the type specimens collected on Long's 1823 expedition, and to correlate any information on their labels with Schweinitz's published *Catalogue,* Keating's *Narrative,* Schweinitz's original handwritten manuscript of the *Catalogue,* and the Systematically Arranged Catalogue of the Schweinitz Herbarium (Schweinitz, unpublished and undated), the latter two being in the manuscript collection in the Academy's library. Thirteen type specimens were found, representing all the new taxa except *Crataegus flexuosus, Vicia tridentata,* and *Hieracium canadense* β *scabrum.*

In the annotated list below, the data on the labels of these type specimens are quoted. As described by Pennell (1935) and Stuckey (1967), the

data with the specimens in Schweinitz's herbarium are meager and cryptic. The specimens taken on Long's Expedition also have cryptic data, consisting of only the name of the species, a notation of the fact that they were taken on the Long Expedition, and sometimes a number and general location. The handwriting, unless otherwise noted, is that of Schweinitz. Data following "Hab." are from Schweinitz's *Catalogue.* Where localities are given in the *Catalogue* or on the specimen label, I have added the approximate date or dates when the plant was collected, based on the expedition's itinerary given in the *Narrative* by Keating. All of the taxa are listed in Schweinitz's Herbarium Catalogue (unpublished) except *Apocynum androsaemifolium β pubescens, Ranunculus filiformis β hispidus,* and *Vernonia corymbosa,* but unfortunately no additional data can be supplied from this Catalogue, as most of the identifying notes accompanying the entries read simply, "Long's Exped."

ANNOTATED LIST OF NEW TAXA[2] DESCRIBED BY SCHWEINITZ FROM LONG'S 1823 EXPEDITION

4. *Cyperus *alterniflorus* Schwein. in Keat., Narrative . . . p. 381. 1824. p. 106-107. 1825. = *C. schweinitzii* Torrey
"Cyperus alterniflorus LvS Longs Exped. Winnipeg Lake" 18-19 Aug.
Hab. No information.
Because of the existence of *Cyperus alterniflorus* R. Br. (Prodr. 216. 1810), Torrey renamed *C. alterniflorus* Schwein. in Keat. as *C. schweinitzii* based on the Schweinitz type (Ann. Lyc. Nat. Hist. N. Y. 3: 276. 1836).

5. *Eriophorum angustifolium* [Honckeny] *β *megastachyon* Nutt. in Schwein. in Keat., Narrative . . . p. 381-382. 1824. p. 107-108. 1825. = *E. viridi-carinatum* (Engelm.) Fernald (det. M. L. F[ernald], without date).
" '5' Eriophorum angustifolium β *megastachyon [in Nuttall's writing] Long's 2d Exped. [in Schweinitz's writing]" 29 May-4 Jun.
Hab. Prairies between Fort Wayne and Lake Michigan.
Although the specimen was annotated by Fernald, he did not include it in his list of specimen citations and omitted the name from the list of synonyms (Rhodora 7: 89-91. 1905).

13. *Triticum *pauciflorum* Schwein. in Keat., Narrative . . . p. 383. 1824. p. 108. 1825. = *Agropyron trachycaulum* (Link.) Malte. (det. M. L. F[ernald], 1932); *fide* Fernald, Rhodora 36: 417-420. 1934; Hitchcock & Chase, Man. Grasses. 2nd. ed., p. 801. 1950.
"Triticum pauciflorum LvS [two illegible words]" 9-22 Jul.
Hab. Prairies of the St. Peter.

26. *Apocynum androsaemifolium* [L.] *β pubescens* Schwein. in Keat., Narrative . . . p. 384. 1824. p. 109-110. 1825.

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[2]One new combination is also included.

"25 Apocynum androsaemifol[ium] (Long's exp)"
Hab. No information.

This variety has not been listed in the Gray Card Index and was not considered by Woodson (Ann. Missouri Bot. Gard. 17: 1-212. 1930; N. Am. Fl. 29: 103-192. 1938).

28. *Gentiana *rubricaulis* Schwein. in Keat., Narrative . . . p. 384-385. 1824. p. 110. 1825. !James S. Pringle, 21 Jun 1965, but not cited by him (Brittonia 19: 23-24. 1967).
"27 Gentiana *rubricaulis Long's 2d Expd." 9-22 Jul.
Hab. Prairies of St. Peter's River.

43. *Prunus *incana* Schwein. in Keat., Narrative . . . p. 387. 1824. p. 111-112. 1825. = *P. pumila* Michaux; *fide* Wight, U. S. Dep. Agr. Bull. 179: 65. 1915.
"Prunus incana LvS Lake of the Woods Longs Exped." 25-27 Aug.
Hab. Islands in the Lake of the Woods.

46. *Crataegus *flexuosus* Schwein. in Keat., Narrative . . . p. 387-388. 1824. p. 112. 1825.
Specimen not found. 31 Aug.-3 Sept.
Hab. Near Rainy Lake.

50. *Rosa *sayi* Schwein. in Keat., Narrative . . . p. 388-389. 1824. p. 113. 1825. = *R. acicularis* Lindl. subsp. *sayi* (Schwein. in Keat.) W. H. Lewis. (The second specimen det. W. H. Lewis, 1956); *fide* Lewis, Brittonia 11: 19. 1959.
"49 Rosa *Sayi Long's 2d Exped"
" 'Rosa Sayi LvS Long's Exp' (herb Schw) [Charles Pickering's writing]"
Hab. No information but Lewis (Brittonia 11: 20. 1959) quotes the location as "Mouth of the St. Peter River: 44° 53′ 49″ N; 93° 8′ 7″ W."; this location has nothing to do with the type locality (Lewis, *in litt.*, 24 Oct. 1969). In the *Narrative,* Keating (1825, Vol. 1, p. 255) wrote: "The eye is charmed by the abundance of wild roses which are strewed over the country, . . ." This location was between Prairie du Chien and Fort St. Anthony.

51. *Potentilla fruticosa* [L.] var. *floribunda* (Pursh) Schwein. in Keat., Narrative . . . p. 389. 1824. p. 113. 1825.

This new combination is based on *Potentilla floribunda* Pursh, Fl. Am. Sept. 1: 355. "1814" [1813]. It has not been listed in the Gray Card Index and was not considered by Rydberg (Mem. Bot. Columbia Univ. 2: 1-233. 1898; N. Am. Fl. 22: 239-533. 1908) or by Wolf (Bibl. Bot. 71: 1-714. 1908).

57. *Ranunculus filiformis* [Michx.] β **hispidus* Schwein. in Keat., Narrative . . . p. 389-390. 1824. p. 114. 1825. = *R. reptans* L.
"56 Ranunculus filiformis β *hispidus [Schweinitz's writing] (Long's exp.) [Pickering's writing]."

Hab. No information.

This variety is not considered by Benson (Am. Midl. Nat. 40: 1-261. 1948).

60. *Stachys *velutina* Schwein. in Keat., Narrative . . . p. 390. 1824. p. 114. 1825. = *Stachys ambigua* Smith in Engl. (det. C. Epling, 1932); *fide* Epling, Fedde repert. Sp. Nov. Beih. 80: 64. 1934.

"Stachys velutina Longs Exp."

Hab. No information.

63. *Melampyrum *brachiatum* Schwein. in Keat., Narrative . . . p. 391. 1824. p. 115. 1825. = *M. lineare* Desv. var. *typicum [lineare]* (Both det. *M. lineare* Desv., F. W. P[ennell], 1933); *fide* Pennell, Monogr. Acad. Nat. Sci. Phila. 1: 509. 1935.

"62 Melampyrum *brachiatum Long's 2^{d} Exped"

"Say Head of Miss [source of St. Peter's River] Melampyrum aut nov Gen" 22-25 Jul.

Hab. No information.

73. *Vicia *tridentata* Schwein. in Keat., Narrative . . . p. 392-393. 1824. p. 116. 1825. = *V. americana* Muhl. ex Willd. var. *minor* Hook. *fide* Hermann, U. S. Dep. Agr. Handb. 168: 84. 1960.

Specimen not found. 31 Aug.-3 Sept.

Hab. Rainy Lake.

80. *Hieracium canadense* [Michx.] β var. *scabrum* Schwein. in Keat., Narrative . . . p. 394. 1824. p. 117. 1825. = *H. scabriusculum* Schwein. in Keat. var. *scabrum* (Schwein. in Keat.) LePage; *fide* LePage, Nat. Canad. 87: 67. 1960.

Specimen not found.

Hab. No information.

LePage does not cite Schweinitz's specimen.

81. *Hieracium *scabriusculum* Schwein. in Keat., Narrative . . . p. 394. 1824. p. 117-118. 1825.

"80 Hieracium *scabriusculum Long's Exped" A second sheet bears similar data but lacks the number 80 and the asterisk.

Hab. No information.

Although LePage annotated these specimens in 1959 as *H. scabriusculum,* he did not mark either one as a type and did not cite them in his publication (Nat. Canad. 87: 62-71. 1960).

83. *Vernonia *corymbosa* Schwein. in Keat., Narrative . . . p. 394-395. p. 118. 1825. = *V. corymbosa* Schwein. in Keat.; *fide* Gleason, Bull. N. Y. Bot. Gard. 4: 209. 1906.

"82 Vernonia *corymbosa Long's 2^{d} Expedit."

Hab. No information.

86. *Erigeron canadense* [L.] **β grandiflorum* Schwein. in Keat., Narrative . . . p. 395. 1824. p. 118-119. 1825. = *Conyza canadensis* (L.)

Cronquist; in accordance with the viewpoint of Cronquist, Bull. Torrey Bot. Club 70: 632. 1943.

"85 Erigeron canadense *β grandiflorum (Long's exp.)" A second sheet bears similar data, but lacks the number 85 and the specific and varietal epithets.

Hab. No information.

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A PRELIMINARY REPORT ON THE VARIETIES OF *MAIANTHEMUM CANADENSE* IN NORTHERN MICHIGAN[1]

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Maianthemum, a small circumboreal genus, is noted among the Liliaceae for having its flower parts arranged in multiples of two. Differences between the species are slight, and have caused some argument (Farwell, 1915). Nevertheless, three species are generally recognized. *M. bifolium* occurs in Europe and Asia, *M. dilatatum* occurs along the Pacific coasts of both Asia and North America, and *M. canadense* extends from Labrador south to upland Georgia and westward to northern British Columbia, south to southern Alberta. On the basis of pubescence found on the undersurface of the leaves of *M. canadense* growing in the western part of its range, Fernald (1914) described var. *interius.* Butters (1927) listed many other characters separating the two varieties. He found no evidence of ecological preferences, and when the two varieties were occasionally found growing together in Wisconsin and Minnesota, few intermediate forms were noted.

The purpose of this investigation was to study the occurrence and possible intergradation of the varieties in the vicinity of the University of Michigan Biological Station. Previous investigations (Butters, 1926) and herbarium records indicated the presence of both varieties throughout the state, and specifically in Emmet and Cheboygan counties, the area surrounding the Biological Station.

A wide range of habitats was sampled in 1969 in both counties. *Maianthemum* is nearly ubiquitous, occurring commonly in all shaded habitats except very dry aspen woods and jack pine forests. At each study area, large numbers of specimens were collected for the purpose of analyzing the variation occurring in that area. Representative samples of these collections have been deposited in the University of Michigan Biological Station Herbarium. Because many of the previously described differences between the varieties were based on flower and inflorescence characters, collections intended for verification of these differences consisted primarily of blooming individuals. No differences between the varieties were restricted to the leaves of sterile shoots. Uprooted rhizomes were extensive, and invariably broke before the entire length of the rhizome could be exhumed. These rhizomes produced both fertile shoots and sterile shoots with a single leaf. Because of the clonal nature of the plant, and the difficulty of distinguishing between the clones, no attempt to apply precise sampling methods was made. Only in those areas where both varieties were found growing together was the presence of two clones definitely indicated. In these areas bias was minimized because of the superficial similarity of the two varieties, in spite of Butters' remark, ". . . these two plants are so distinct even though they are occasionally found growing side by side, as to give one the feeling that they are to be regarded as species rather than varieties."

[1]Contribution from the Biological Station of The University of Michigan.

Failure to detect ecological preference on the part of either variety was the most immediate result of this study. Although Baldwin (1958) stated that in the clay belt of northern Ontario and Quebec var. *interius* preferred drier woodland habitats than var. *canadense,* no such preference was found in the area studied. In northern Michigan both varieties occur in aspen-pine woodlands, coniferous forest bordering the Straits of Mackinac, northern hardwood associations, and also in bog forests consisting of *Thuja, Abies,* and *Picea.* In the forest surrounding Galloway Lake bog north of Levering, Emmet Co., var. *interius* was growing on a rotting stump almost completely surrounded by open water. In each of these major habitats where *M. canadense* was found, both varieties grew together in at least one area, in some cases to the extent that the rhizomes were densely intermingled.

Butters (1927) cited numerous differences between the two varieties. He stated that generally var. *interius* was taller than var. *canadense,* and produced more flowers in a denser inflorescence, although the length of the inflorescence of var. *interius* was usually greater. In addition, the leaves of var. *interius* were supposedly more cordate than the typical form, with the secondary veins and commissures of var. *interius* more obscure than those of var. *canadense.* Compared to var. *canadense,* Butters found the leaves of var. *interius* to be more plicate. He also stated that var. *canadense* typically bloomed somewhat earlier than var. *interius.* Minute differences in flowers and rhizome anatomy were also cited. Fernald (1950) stated that the leaves of var. *interius* were usually a darker blue-green compared to those of var. *canadense.*

In order to determine the validity of these claims, measurements of four characters were made from specimens in the University of Michigan Herbarium, and the Michigan State University Herbarium. Specimens measured were primarily from Michigan, but collections from other parts of the United States and Canada were also used. The characters recorded are shown in Table I, where the results are summarized. Statistically significant differences were obtained in all cases, and the measurements agreed with Butters' results. How-

TABLE I. Character values based on specimens of *Maianthemum canadense* from the herbaria of the University of Michigan and Michigan State University.

Variety	1. Overall height	2. No. of flowers per inflorescence	3. Inflorescence length versus no. of flowers			4. Angle of the apex of the lowest leaf
			No. of plants	Length of raceme	Average no. of flowers	
M. canadense var. *canadense* (Values averaged on the basis of 210 specimens.)	13 cm	20	2	4-5 cm	23	52°
			36	3-4 cm	24	
			131	2-3 cm	20	
			41	1-2 cm	17	
M. canadense var. *interius* (Values averaged on the basis of 126 specimens.)	17 cm	27	1	5-6 cm	32	65°
			19	4-5 cm	38	
			46	3-4 cm	29	
			48	2-3 cm	24	
			12	1-2 cm	22	

ever, the leaf angle character was very unsatisfactory. The average difference was so slight, and the individual variation so great, that no general impression of consistant differences could be gained by looking at the leaves of the two varieties.

In addition to these characters, other differences mentioned by Butters were verified by specimens collected in Emmet and Cheboygan counties. The intermediate veins and commisures of var. *interius* were distinctly more obscure than those of var. *canadense.* However, the leaves of var. *interius* did not appear to be more plicate than leaves of the typical form. Butters' statement that the anthers of var. *interius* are clavate, compared to the subulate form of anthers of var. *canadense,* did not appear to be borne out. Neither was any consistent difference in the pistils of the two varieties evident, although Butters claimed that the pistil of var. *interius* is more prominent and deeply two-lobed. Other characters mentioned by Butters and Fernald appear much more variable. This is especially true in the case of leaf shape. In some populations of var *interius,* the leaves are very acute, and in other populations they are blunt and more cordate. The same range of variation also occurs with var. *canadense.* In some areas, acute-leaved var. *interius* occurs together with blunt-leaved var. *canadense,* a situation exactly opposite from that described by Butters. Similarly, although color differences between the leaves of the varieties are encountered, the differences are not stable and may be totally reversed from one situation to the next.

The most interesting variation is in the range of flowering periods. On

Fig. 1. *Maianthemum canadense* var. *interius* (three plants at left) and var. *canadense* collected at Readmond Township Park, Emmet County, Michigan, June 13, 1969. Nearly all the flowers of var. *interius* are open. Flowers of var. *canadense* are still in young bud. The more broadly cordate shape of the leaves of var. *interius* is also evident. Photographed by Gary R. Williams.

several occasions, var. *interius* has been reported to flower as much as two weeks later than var. *canadense* (Butters, 1927; Ingram, 1966; Morley, 1969). In this study a fixed relation between the blooming periods of the two varieties was not found. In some situations where they were found growing together, both varieties flowered at the same time; in others, var *interius* bloomed later than or before the typical variety (Fig. 1). In populations where both of the varieties occur together, and the blooming periods overlapped, intermediate plants were found. These are assumed to be hybrids because they are intermediate in amount of pubescence, height, and number of flowers. The number of intermediates varied according to the degree of overlap in flowering. In areas where little overlap occurred, few putative hybrids were present. Conversely, where overlap was complete, large numbers of intermediates were found. Measurements similar to those made on herbarium specimens from throughout the range of the two taxa were made on the plants collected in Emmet and Cheboygan counties. Differences between the varieties have apparently not been affected by extensive hybridization. Statistics based on the plants collected during this study compare closely with measurements of specimens from throughout the range of the taxa (see Table II). This fact, and the large numbers of putative hybrids found in Emmet and Cheboygan counties, indicate the possible occurrence of hybrids wherever the varieties grow together. However, this is not suggested from herbarium records. In the University of Michigan Herbarium only 11 intermediate specimens were found among 317 specimens examined of both varieties of *M. canadense.* Lack of extensive collecting in a particular area and the clonal nature of the species probably contribute to this situation.

Butters states that in Minnesota intermediate forms "are very rare and can easily be explained as hybrids." He makes this claim on the basis of infertile pollen taken from intermediate forms. Pollen was not examined in this study, but an attempt was made to show the occurrence of introgressive hybridization, which was suggested by the widely differing degrees of pubescence. Four groups of putative hybrids were recognized, as listed in Table III. A certain amount of bias in recording the data was unavoidable, because of the difficulty of distinguishing between group 4 and var. *interius.* To some extent, this probably accounts for the greater numbers of individuals in groups 1 and 2, where the degree of pubescence is much easier to categorize. The heights and number of flowers of individuals in each group were measured to determine possible correlations between variation of these characters with vari-

TABLE II. Character values based on specimens of *Maianthemum canadense* collected in Emmet and Cheboygan counties. (Because the overall height and number of flowers per inflorescence probably reflect the length of the inflorescence, this character was not measured for these plants. The leaf angle character was eliminated because of its unreliability.)

Variety	Overall height	Number of flowers per inflorescence
var. *canadense* (Values averaged on the basis of 203 specimens.)	13 cm.	21
var. *interius* (Values averaged on the basis of 122 specimens.)	17 cm.	25

TABLE III. Average height and number of flowers for groups of putative hybrids between *Maianthemum canadense* var. *canadense* and *M. canadense* var. *interius,* separated by differing degrees of pubescence.

Amount of pubescence	Height	No. of flowers per inflorescence
1. Leaf margins and petioles minutely pubescent (based on 77 specimens)	16	23.6
2. Pubescence longer and thicker, but still confined to the leaf margins and petioles (based on 70 specimens)	15.5	23.4
3. Pubescence same length as in group 2, but covering the basal portion of the undersurface of the leaves as well as the leaf margins and petioles (based on 37 specimens)	15.9	25.9
4. Entire undersurface of leaf pubescent in addition to leaf margins and petioles. Pubescence on basal portion of leaves similar in length to basal leaf pubescence in group 3, but more abundant. Pubescence on distal portion of leaves shorter and more thinly distributed than in var. *interius* (based on 49 specimens)	16.2	25.0

ation of pubescence (see Table III). It was expected that correlations between these characters would appear, but none were found.

SUMMARY

In Emmet and Cheboygan counties, Michigan, differing habitat preferences between the two varieties of *Maianthemum canadense* do not seem to exist. Some morphological differences cited by former workers were verified. Blooming time varied widely in both varieties, and this variation directly influenced the formation of intermediates. These putative hybrids were found when overlap in blooming periods occurred. When the varieties bloomed at distinctly different times, very few intermediates were present. Because of the widely differing degrees of pubescence shown by the putative hybrids, introgressive hybridization was suggested, but not adequately demonstrated.

ACKNOWLEDGMENTS

I wish to thank Edward G. Voss for his considerable aid throughout the course of this research and also Gary R. Williams for the photograph. The work was supported in part by NSF grant GB-8440 to the University of Michigan Biological Station.

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THE BARNES HYBRID ASPEN, *POPULUS* ×*BARNESII*, HYBR. NOV. – A NOMENCLATURAL CASE IN POINT

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Natural hybrids are much more common in plants than animals. In some groups like the ferns as many as 20 per cent of the "kinds" in a flora may be hybrids. Among trees of the Great Lakes area, such hybrids as black times sugar maple, *Acer nigrum* × *saccharum,* produce such a confusing array of intermediates that some collectors doubt whether the parents are true species. Others of our native hybrids, such as Bebb's oak, *Quercus* ×*bebbiana* (*Q. alba* × *macrocarpa*) and the Purpus birch, *Betula* ×*purpusii* (*B. alleghaniensis* × *pumila*) are so well marked that the competent dendrologist recognizes them immediately. I wish to describe another well defined hybrid tree of this region here.

First it should be stated that from a number of standpoints, hybrids are often inconvenient and troublesome to field workers, taxonomists, and evolutionists. For example, crosses are hard to key out in many cases, and they tend to blur the distinctions of normal species; for in practically all respects, hybrids tend to be intermediate between their parents. This fact has caused wide variation in nomenclatural usage (Wagner, 1968, 1969). The hybrid aspen to be designated below might be named (1) as a variety of *Populus grandidentata;* (2) as a variety of *P. tremuloides,* its other parent; or (3) as one of three varieties, the parents and the hybrid, of a single species; (4) by its formula, *P. grandidentata* × *tremuloides;* (5) by a straight binomial, as if it were a normal species; or (6) by a hybrid binomial, i.e., interpolating the multiplication sign to indicate its origin. It seems hard to believe that authors find arguments to support each of these different methods. I personally believe that a hybrid binomial should be used for all hybrids except those so rare that they are not likely to be encountered. Whatever we do, designation of hybrids should be convenient; the name should be a useful handle for denoting the plant. It should be stable, so that the name will not have to be changed in future. And it should be meaningful, i.e., we should be able to tell right away whether the plant named is a species or hybrid.

The plant we have been referring to clumsily as *Populus grandidentata* × *tremuloides* is now known to be widespread and locally common in the Upper Great Lakes and elsewhere in the eastern United States. Dr. Burton V. Barnes, who has been studying it intensively for over a decade in connection with his broader researches on biology and classification of poplars and aspens, reports numerous localities in Michigan (cf. Barnes, 1961, 1967; Andrejak and Barnes, 1969). The hybrid aspen ranges from Minnesota to New England (Pauley, 1956; Barnes, pers. comm.). In my own field work in Michigan I have observed it so many times I no longer bother to collect it. At least in southern

Michigan, I do not doubt that it will be found in every county. It occurs especially in second-growth communities, especially woods along railroads, edges of fields, and along streams and rivers where there has been much past disturbance. One professor of my acquaintance, unaware of the widespread presence of this plant, thought it was a rarity. Indeed, when he began taking classes to one of his favorite localities, he taught the hybrid as "*P. grandidentata*" because trees of that species were not present nearby, only *P. tremuloides*. Compared to the latter, the misidentified trees did have leaves with "fewer and larger teeth."

It must not be overlooked that all of our aspens form large stands by root suckering (Barnes, 1966). A single aspen hybrid in this way can theoretically produce dozens of trees by vegetative propagation underground. An aspen woods is not made of individual trees that came from separate seeds; only one or a few original plants can produce a large stand.

I have argued elsewhere (Wagner, op. cit.) that the hybrid binomial has certain advantages over other methods of designating hybrids. One can quickly refer to a specimen in teaching and discussion, using a stable name. And if we install the × sign, it immediately tells that the plant is a "between species," a special kind of taxon differing in various respects from normal species. I believe that Barnes' hybrid aspen is a good case in point and accordingly propose that this plant be given a hybrid binomial. The choice of epithet is appropriate because Dr. Barnes has made the bulk of contributions to our knowledge of this plant, and most of the literature is to be found under his name.

Populus ×**barnesii** W. H. Wagner, hybr. nov. Arbor clones faciens, inter *P. grandidentatum* et *P. tremuloidem* media, gemmis tomentellis, foliorum petiolis 3-6 cm longis, laminis ovatis vel subdeltoideis vel suborbicularibus, acuminatis, 4-9 cm longis, 3.5-7.5 cm latis, dentibus marginalibus, 12-25 in quoque margine, aliquantum irregularibus et sinubus rotundatis 0.5-3.0 mm. profundis separatis.

Type: Michigan, Washtenaw County, Waterloo Recreation Area (NE¼SE¼ sec. 9, T2S, R3E). Barnes no. 65W88. (Holotype MICH; isotypes NY, UC, US, WTU).

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Nature education feature --

WINTER FIELD KEY TO SOME TREES COMMON IN MICHIGAN

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The increasing interest in environmental education brings to mind that the winter season is too often neglected for its potential value in nature education. Our various parks and recreation areas are open in the winter and their trails provide easy access to an outdoor laboratory for winter botany.

Perhaps trees in the winter condition are a most suitable point of departure for the student of plant science during this season. In winter, as in any other season, trees constitute the most conspicuous part of many plant communities. It should be borne in mind that one does not really "know" a tree when a scientific or common name can be associated with certain leaf characters. To really "know" a tree one should be able to recognize and identify it during all seasonal aspects as well as in youth, maturity, and old age. I wonder how many of us are able to recognize genera of trees on the basis of flower characters alone, for instance.

In addition to the well-known *Michigan Trees* by C. H. Otis (9th ed., University of Michigan Press, 1931), the selected references listed and annotated below are suitable for use in the western Great Lakes area, as all apply to the eastern or northeastern States. All are illustrated. It is intended that at least one of these references be available as a field manual and thus a supplement to this "first key" to trees in the winter condition in this area. I therefore have omitted a glossary, drawings, and photographs, as well as citation of authorities following scientific names.

Core, Earl L., and Nellie P. Ammons. 1958. *Woody Plants in Winter.* 218 pp. The Boxwood Press, P.O. Box 1717, Pittsburgh, Pa. 15213. Clothbound $4.00; paper $2.75.

This handy volume is, in my opinion, the best single "field manual" reference for native woody plants in the winter condition in the western Great Lakes area. As its title implies, shrubs are treated, as well as certain vines and trees. Some plants which have been introduced are included. It is profusely illustrated by line drawings.

Trelease, William. 1931. *Winter Botany.* 3rd rev. ed. 396 pp. Reprinted 1967 by Dover Publications, Inc., 180 Varick St., New York, N. Y. 10014. $2.00 (paper bound).

This volume lists over 1000 woody plants, including some escaped species and vines. Conifers are excluded. Perhaps the strongest point of this volume is the line drawings, which are particularly diagnostic at the generic level.

Harlow, William M. 1959. *Fruit and Twig Key.* 50 + 56 pp. Dover Publications, Inc. (address above). $1.35 (paper bound).

This small volume is a reprint of two earlier publications: 1) a fruit key (1946) which treats both deciduous and evergreen tree species in its 50 pages; 2) keys (1954) to deciduous woody plants (both trees and shrubs) based on twig characters. In all there are over 350 photographs, some of which are of questionable value. This book might well be used as an additional reference with either of the preceding books.

Symonds, George W. D. 1958. *The Tree Identification Book.* 272 pp. M. Barrows and Co., 425 Park Ave. S., New York, N. Y. 10016. $10.00 (cloth bound).

This book, along with its companion volume, *The Shrub Identification Book* (379 pp.) by the same author and publisher but $15.00, clearly provides the practical approach to woody plant identification. While keys in the traditional couplet sense are not included there are in each several "keys" based on such characters as thorns, leaves, twigs and buds, bark, and flowers. These separate keys are essentially photographic treatments (in black and white) and the photographs in the shrub book are of somewhat better quality than those in the book on trees. In both volumes species that are strictly southern or subtropical are omitted, as are hybrids in general and certain genera whose species are very numerous, e.g., *Crataegus* (hawthorn). Although several dozens of species of oaks occur in eastern North America and adjacent Canada, only nine species are included. In each volume both popular and scientific names are given.

KEY

1. Leaves evergreen, persisting through winter 2
1. Leaves deciduous, not persisting through winter 8

2. Leaves scale-like or awl-shaped, opposite or whorled 3
2. Leaves linear, needle-like, alternate or in bunches of 2-5 4

3. Leaves all scale-like, branchlets flattened . . . . . *Thuja occidentalis* (arbor vitae)
3. Leaves all or in part awl-shaped; branchlets not strongly flattened . . . . . *Juniperus virginiana* (red cedar)

4. Leaves in bunches of 2-5 on dwarf branches . . . . . *Pinus* spp. (pine)
4. Leaves alternate, not in bunches on dwarf branches 5

5. Leaves 4-sided in cross section . . . . . *Picea* spp. (spruce)
5. Leaves in cross section flattened from top to bottom 6

6. Leaves of 2 lengths, those on the upper side of twig shorter than those on lower side of twig . . . . . *Tsuga canadensis* (hemlock)
6. Leaves of about equal length 7

7. Branchlets flexible; cones hanging, 3-pronged bracts conspicuous beyond cone scales; leaf stalks remaining on twigs after leaves have fallen . . . . . **Pseudotsuga menziesii* (Douglas fir)
7. Branchlets stiff; cones erect, 3-pronged bracts absent; leaf stalks absent . . . . . *Abies balsamea* (balsam fir)

8. Dwarf branches bearing crowded leaf scars; gymnosperms 9
8. Dwarf branches, if present, lacking crowded leaf scars; angiosperms 10

9. Bundle scars 2; leaf bases not persisting as ridges down the stem . . . . . **Ginkgo biloba* (ginkgo)
9. Bundle scar 1; leaf bases persisting as ridges down the stem . . . *Larix laricina* (larch)

10. Leaf scars whorled . . . . . *Catalpa* spp. (catalpa)
10. Leaf scars opposite or alternate 11

11. Leaf scars opposite 12
11. Leaf scars alternate 15

12. Twigs stout; terminal bud about 1 cm long or longer, its 10-12 scales sometimes sticky . . . . . *Aesculus* spp. (*Horse chestnut, buckeye)
12. Twigs not stout; terminal bud shorter, its scales fewer, not sticky 13

13. Bud scales hairy or rough, brownish-black; bundle scars more than 3 . . . . . *Fraxinus* spp. (ash)
13. Bud scales not hairy nor rough, reddish or gray; bundle scars 3 14

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*Tree species not native in Michigan.

14. Visible bud scales 2; leaf scars slightly raised, the 2 opposing scars joined by a line but not meeting around the stem . . . . . *Cornus* spp. (dogwood)
14. Visible bud scales usually more than 2; leaf scars not raised; often meeting around the stem . . . . . *Acer* spp. (maple)

15. Twigs with thorns 16
15. Twigs without thorns 21

16. Sap milky; thorns usually 1 per axil . . . . . **Maclura pomifera* (osage orange)
16. Sap not milky; thorns not single at each axil 17

17. Axillary buds within leaf scar 18
17. Axillary buds not within leaf scar 19

18. Thorns usually branched . . . . . *Gleditsia triacanthos* (honey locust)
18. Thorns unbranched, in pairs opposite leaf scars . . . . . *Robinia pseudoacacia* (black locust)

19. Thorns not formed from modified branch ends . . . . . *Crataegus* spp. (hawthorn)
19. Thorns formed from ends of modified branches 20

20. Stipule scars present; the terminal bud usually absent . . . . . *Prunus* spp. (plum, cherry)
20. Stipule scars absent. the terminal bud present . . . . . **Pyrus communis* (pear)

21. Twigs with stipular rings completely encircling the stem 22
21. Twigs lacking stipular rings which completely encircle the stem 24

22. Leaf scar encircling the lateral bud; terminal bud absent . . . . . *Platanus occidentalis* (sycamore)
22. Leaf scar not encircling the lateral bud 23

23. Leaf scar round; terminal bud scales 2 . . . . . *Liriodendron tulipifera* (tulip tree)
23. Leaf scar not round, often U-shaped; terminal bud scale 1 . . . . . **Magnolia* spp. (magnolia)

24. Buds at least 1 cm long, covered by 20 or more spirally arranged scales; stipular scars almost meeting around the twig . . . . . *Fagus grandifolia* (beech)
24. Buds shorter, scales fewer, and stipular scars not as big 25

25. Leaf scars in 2 ranks 26
25. Leaf scars not in 2 ranks 38

26. Bundle scar 1 or several appearing as 1 . . . . . **Diospyros virginiana* (persimmon)
26. Bundle scars 3 or more, some of them sometimes composed of more than 1 in a close group 27

27. Terminal bud naked 28
27. Terminal bud absent or if present then covered by scales 29

28. Buds yellowish; stipular scars present; pith without diaphragms . . . . . *Hamamelis virginiana* (witch hazel)
28. Buds covered with reddish brown hairs; stipular scars absent; pith sometimes with greenish plates or chambered . . . . . *Asimina triloba* (pawpaw)

29. Stipular scars absent 30
29. Stipular scars present 31

30. Three vertical ridges below leaf scar; terminal bud absent . . . . . *Cercis canadensis* (redbud)
30. Vertical ridges absent; terminal bud present . . . . *Amelanchier* spp. (serviceberry)

31. Bud scales 2; buds slanting sideways; pith not 3-sided . . . *Tilia americana* (basswood)
31. Bud scales more than 2 or if 2 then pith 3-sided; buds sometimes slanting 32

32. Bundle scars 3 or in 3 distinct groups 33
32. Bundle scars more than 3 and not in groups of 3 37

33. Bud scales in 4 ranks; trunk with longitudinal ridges . . . . . *Carpinus caroliniana* (blue-beech, ironwood)
33. Bud scales not 4-ranked; trunk lacking longitudinal ridges 34

34. Bud scales longitudinally striped with fine lines . . . . . *Ostrya virginiana* (hop hornbeam, ironwood)
34. Bud scales without longitudinal stripes 35

35. Terminal bud present; lenticels horizontally elongated; pith 3-sided . . . . . *Betula* spp. (birch)
35. Terminal bud absent; lenticels not horizontally elongated; pith not 3-sided 36

36. Lateral buds appressed; pith chambered . . . . . *Celtis occidentalis* (hackberry)
36. Lateral buds not appressed; pith not chambered . . . . . *Ulmus* spp. (elm)

37. Leaf scar triangular; sap not milky; pith 3-sided . . . . . *Corylus* spp. (hazelnut)
37. Leaf scar rounded; sap milky; pith rounded . . . . . *Morus* spp. (mulberry)

38. Lateral buds superposed 39
38. Lateral buds not superposed 41

39. Pith diaphragmed . . . . . *Juglans* spp. (walnut)
39. Pith not diaphragmed 40

40. Axillary bud contained within the leaf scar; pith not 5-angled nor star-shaped . . . . . *Gleditsia triacanthos* (honey locust)
40. Axillary bud not surrounded by the leaf scar; pith 5-angled or star-shaped . . . . . *Carya* spp. (hickory)

41. Bundle scar 1 or several appearing as one 42
41. Bundle scars more than 1 and separated 43

42. Stipular scars absent; buds not superposed; twigs green and aromatic . . . . . *Sassafras albidum* (sassafras)
42. Stipular scars present; buds often superposed; twigs not green and aromatic . . . . . *Ilex verticillata* (winterberry)

43. Bundle scars 3 or in groups appearing as 3 scars 44
43. Bundle scars more than 3 and separate 49

44. Bud scale 1 . . . . . *Salix* spp. (willow)
44. Bud scales more than 1 45

45. Pith (and sometimes twigs) 3-sided; buds borne on short stalks . . *Alnus* spp. (alder)
45. Pith not 3-sided; buds not stalked 46

46. Bud scales 2 . . . . . *Cornus alternifolia* (alternate-leaved dogwood)
46. Bud scales more than 2 47

47. Pith 5-6-angled and star-shaped; deciduous branch scars present . . . . . *Populus* spp. (aspen, poplar, cottonwood)
47. Pith not 5-6-angled; deciduous branch scars absent 48

48. Stipule scars absent . . . . . **Pyrus* spp. (apple, pear)
48. Stipule scars present . . . . . *Prunus* spp. (cherry, plum)

49. Buds clustered near tip of twig . . . . . *Quercus* spp. (oak)
49. Buds not clustered near tip of twig 50

50. Terminal bud present and large; pith 5-angled or star-shaped . . . . . *Carya* spp. (hickory)
50. Terminal bud usually absent; pith rounded 51

51. Leaf scars U-shaped or round; bundle traces often less than 9; sap resinous, sometimes milky; some species poisonous to the touch . . . . . *Rhus* spp. (sumac)
51. Leaf scars shaped like a shield, notched at top; bundle traces usually more than 9; sap not resinous nor milky . . . . . **Ailanthus altissima* (tree-of-heaven)

MICHIGAN PLANTS IN PRINT

New Literature Relating to Michigan Botany

This section lists new literature relating to Michigan Botany under four categories: A. Maps, Soils, Geography, Geology (new maps and selected bulletins or articles on soils and geology as these may be of use to field naturalists and students of plant distribution); B. Books, Bulletins, etc., and C. Journal Articles (listing, respectively, all separate publications and articles in other periodicals which cite Michigan specimens or include research based on plants of wild origin in Michigan;–not generally including work on cultivated plants nor strictly economic aspects of forestry, conservation, or agriculture); D. History, Biography, Exploration (travels and lives of persons with Michigan botanical connections). When the subject matter or relation to Michigan is not clear from the title, annotations are added in brackets. Readers are urged to call to the editor's attention any titles (1960 or later) which appear to have been overlooked–especially in less well known sources.

A. MAPS, SOILS, GEOGRAPHY, GEOLOGY

Farrand, William R., Robert Zahner, & William S. Benninghoff. 1969. Cary–Port Huron Interstade: Evidence from a buried bryophyte bed, Cheboygan County, Michigan. Geol. Soc. Am. Spec. Pap. 123: 249-262. [Contains important data for interpreting vegetational history in northern Michigan; implies that the Straits of Mackinac were not deglaciated during the Two Creeks Interstade but that drainage then occurred across the Petoskey-Cheboygan lowland. Cf. also paper listed below by Miller & Benninghoff.]

Gair, Jacob E., & Robert E. Thaden. 1968. Geology of the Marquette and Sands Quadrangles, Marquette County, Michigan. U. S. Geol. Surv. Prof. Pap. 397. 77 pp. + pl. in pocket. $3.00 (Govt. Printing Office). [Entirely on bedrock geology, but illustrates algal structures in an ancient chert-dolomite and some maps show topography as well as subsurface features and outcrops.]

Mettert, Wesley. 1969. Soil Survey of Osceola County, Michigan. U. S. Dep. Agr. 149 pp. + 96 once-folded map plates + 6 folded tables and indexes. $6.00 (Govt. Printing Office). [Another of the new soil surveys including complete aerial photographic coverage for the county, at a scale of about 4″ = 1 mile, with boundaries of soil types overprinted. Will be indispensable guide to locating the numerous fine woodlots in this county.]

Whiteside, E. P., I. F. Schneider, & R. L. Cook. 1968. Soils of Michigan. Mich. Agr. Exp. Sta. Ext. Bull. E-630. 52 pp. + folded map. [An almost unaltered new edition of former Spec. Bull. 402, with the same colored map of major Michigan soil associations. A good general introduction to Michigan soils, available at county offices of the Michigan State Cooperative Extension Service or from MSU Bulletin Office, Box 231, East Lansing 48823.]

B. BOOKS, BULLETINS, SEPARATE PUBLICATIONS

Edman, F. Robert. 1969. A Study of Wild Rice in Minnesota; Minnesota Resources Commission, State Capitol, St. Paul. 110 + xii pp. (processed). [A compilation which includes 6 pages of somewhat garbled data on distribution of wild rice in Michigan.]

Gillett, John M. 1968. The Milkworts of Canada. Canada Dep. Agr. Monogr. 5. 24 pp. [A handy treatment of *Polygala,* including keys, drawings, and distribution maps. The latter indicate a few Michigan locations for five of the species. The only Michigan species in the genus which apparently is not found in Canada is *P. cruciata,* which ranges as close as Algonac (St. Clair Co.) and Monroe Co. Available from Information Division, Canada Department of Agriculture, Ottawa.]

Heiser, Charles B., Jr., with Dale M. Smith, Sarah B. Clevenger, & William C. Martin, Jr. 1969. The North American Sunflowers (Helianthus). Mem. Torrey Bot. Club 22(3). 218 pp. $5.00. [A thorough summary of present knowledge of this difficult genus,

with keys and distribution maps, the latter showing Michigan stations for many of the species.]

Schuyler, Alfred E. 1969. Three New Species of Scirpus (Cyperaceae) in the Southern United States. Not. Nat. 423. 12 pp. [Cites Muskegon County records for related *S. hallii* and illustrates achenes of one of them.]

Smith, Alexander H., & L. R. Hesler. 1969. The North American Species of Pholiota. Hafner Publ. Co., New York. 402 pp. + 90 pl. $22.50. [A thorough monograph, with many taxa including numerous new ones cited from Michigan—the new ones from definite localities. The plates all consist of photographs of these mushrooms.]

Tubbs, Carl H. 1969. The Influence of Light, Moisture, and Seedbed on Yellow Birch Regeneration. North Central For. Exp. Sta., U. S. For. Serv. Res. Pap. NC-27. 12 pp. [Study made in a forest opening on the Upper Peninsula Experimental Forest near Skandia (Marquette Co.).]

C. JOURNAL ARTICLES

Erbisch, Frederic H. 1969. Ascus and ascospore development of five species of the lichen-forming genus Pertusaria. Bryologist 72: 178-199. ["All species examined were collected in Michigan, in both upper and lower peninsulas."—no further locality data.]

Genys, John B. 1968. Geographic variation in eastern white pine. Silvae Genet. 17: 6-12. [Three of the 99 sources of seed grown in Maryland were in Michigan; data on 9 characters given in a table.]

Gibbons, J. Whitfield. 1968. Reproductive potential, activity, and cycles in the painted turtle, Chrysemys picta. Ecology 49: 399-409. [Includes mention of common plants of Sherriff's Marsh and Wintergreen Lake, T. 1 S., R. 9 W., Kalamazoo Co.]

Hagenah, Dale J. 1969. Polypodium virginianum not restricted to rocky habitats. Am. Fern Jour. 59: 80-81. [Documents with citation of several Michigan collections the occurrence of this species on sand, gravel, and rotten logs.]

Hennen, Joe F., & George B. Cummins. 1969. The autoecious species of Puccinia and Uromyces on North American Senecioneae. Mycologia 61: 340-356. [Cites and illustrates teliospores of type material of *P. recedens* from *Senecio aureus* at Ann Arbor.]

Herbst, Richard P. 1969. Ecological factors and the distribution of *Cladophora glomerata* in the Great Lakes. Am. Midl. Nat. 82: 90-98. [Includes brief report on "massive growths" of this alga at cities along eastern shore of Lake Michigan.]

Ireland, Robert R. 1969. Taxonomic studies on the genus Atrichum in North America. Canad. Jour. Bot. 47: 353-368. [One Michigan collection is cited for each of three of the species in this moss genus.]

Kimbrough, James W. 1969. North American species of Thecotheus (Pezizeae, Pezizaceae). Mycologia 61: 99-114. [*T. apiculatus,* a new species from Ontario, cited also from Ann Arbor.]

Koponen, Timo. 1968. The moss genus Rhizomnium (Broth.) Kop., with description of R. perssonii, species nova. Mem. Soc. Fauna Fl. Fenn. 44: 33-50. [Specimens of the new species are said to have been seen from several North American states and provinces, including Michigan, but Eurasian material is cited.]

Miller, Norton G., & William S. Benninghoff. 1969. Plant fossils from a Cary-Port Huron Interstade deposit and their paleoecological interpretation. Geol. Soc. Am. Spec. Pap. 123: 225-248. [Site was not far north of Douglas Lake, Cheboygan County; species reported from deposit 12,500-13,300 years old which are now characteristics of northern boreal coniferous forest, forest-tundra ecotone, and adjacent tundra of the far north. Cf. paper cited under "A" above by Farrand et al.]

Miller, O. K., & Roy Watling. 1968. The status of Boletus calopus Fr. in North America. Notes Roy. Bot. Gard. Edinburgh 28: 317-325. [This species not known in eastern North America; material identified as it or the synonymous *B. pachypus* (including collection cited from Sault Ste. Marie, Michigan) is different.]

Miller, Philip C., & David M. Gates. 1967. Transpiration resistance of plants. Am. Midl. Nat. 77: 77-85. [Field studies of energy budget of several species in Emmet and Cheboygan counties.]

Pringle, James S. 1969. Documented plant chromosome numbers 1969:1. Sida 3: 350-351. [Includes count of n = 26 for *Potamogeton gramineus* from Cheboygan County, with tracing from photomicrograph.]

Smithberg, Margaret H., & Conrad J. Weiser. 1968. Patterns of variation among climatic races of red-osier dogwood. Ecology 49: 495-505. [One of 21 clones studied under uniform conditions in Minnesota was from Cadillac, Michigan.]

Thiers, Harry D., & James M. Trappe. 1969. Studies in the genus Gastroboletus. Brittonia 21: 244-254. [*G. scabrosus* noted from Michigan.]

Thompson, Paul W. 1969. A unique American chestnut grove. Mich. Acad. 1(3-4): 175-178. [Several thousand offspring established from an old planting near Frankfort in Benzie Co.]

Vuilleumier, Beryl Simpson. 1969. The genera of Senecioneae in the southeastern United States. Jour. Arnold Arb. 50: 104-123. [Mentions occurrence of *Arnica cordifolia* on the Keweenaw Peninsula.]

Watling, Roy. 1969. New fungi from Michigan. Notes Roy. Bot. Gard. Edinburgh 29: 59-66.

Watling, Roy. 1969. The genus Paragyrodon. Notes Roy. Bot. Gard. Edinburgh. 29: 67-73. [Many southern Michigan localities, chiefly in Washtenaw County, cited for *P. sphaerosporus.*]

Wells, James R. 1969. A review of the varieties of Polymnia uvedalia. Rhodora 71: 204-211. [Map shows two varieties in southern Michigan.]

Wells, James R. 1969. Specific relationships between Polymnia canadensis and P. laevigata (Compositae). Castanea 34: 179-184. [Distribution map includes 15 Michigan localities for *P. canadensis.*]

Wetzel, Robert G. 1969. Excretion of dissolved organic compounds by aquatic macrophytes. BioScience 19: 539-540. [Laboratory data on *Najas flexilis* from Lawrence Lake, Barry County (see pp. 3-9 in this issue.)]

Wright, H. E., Jr. 1968. The roles of pine and spruce in the forest history of Minnesota and adjacent areas. Ecology 49: 937-955. [Includes consideration of percentages of pine and spruce pollen in Michigan palynological studies.]

Zander, Richard. 1967. The New World distribution of Scopelophila (= Merceya). Bryologist 70: 405-413. [*S. ligulata* cited from Alger Co.]

D. HISTORY, BIOGRAPHY, EXPLORATION

Bliss, Lawrence C. 1969. Henry J. Oosting March 12, 1903 - October 31, 1968. Bull. Torrey Bot. Club 96: 370-372. [Biographical sketch with picture and selected bibliography of the noted ecologist born in Holland, Michigan and a graduate of Hope College (A.B. 1925) and Michigan State (M.S. 1927); his 1932 paper on *Potamogeton* in Michigan is not in the selected bibliography.]

Brockhoff, Dorothy A. 1969. Edgar Anderson 1897-1969. [An appreciative sketch with portrait of one of Michigan State University's best known graduates (B.S. 1918), whose Michigan collections, while locally important, are doubtless one of his least claims to fame; his family ties to Kalamazoo County are not mentioned.]

Degener, Otto. 1968. Earl Edward Sherff (1886-1966). Taxon 17: 189-198. [Biographical sketch, with bibliography and portrait, of Michigan-born botanist who retired to Hastings, Michigan, after a professional career largely in Illinois.]

Fulford, Margaret, & Philip B. Whitford. 1968. In Memoriam Raymond Edward Hatcher (1930-1967). Bryologist 71: 58-59. [Includes photo and bibliography. Hatcher collected bryophytes extensively in Michigan and elsewhere.]

Smith, Alexander H. 1969. Edwin Butterworth Mains 1890-1968. Mycologia 61: 449-451. [Brief biography, with photo, of late director emeritus of the University of Michigan Herbarium.]

Stuckey, Ronald L. 1969. An overlooked plant name (Aesculus maxima) of Daniel Drake and his lost herbarium. Castanea 34: 185-192. [Mentions that the herbarium of the Academy of Natural Sciences of Philadelphia includes some specimens collected by Drake [ca. 1842] at Mackinac Island and Lake Superior, Michigan.]

Information for Authors — The Michigan Botanist

THE MICHIGAN BOTANIST is distributed not only to a considerable number of individual and institutional subscribers domestically and abroad, but also to all members of the Michigan Botanical Club, an organization composed in large part of non-professionals with concerns for conservation and nature study as well as the local flora. (Total paid circulation is about 800.) Considering the range of interests among members and subscribers, we seek to include (in each year if not each issue) the widest possible range of subject matter in regard both to the entire plant kingdom and to branches of the field of botany.

Articles should, in general, include some new botanical information, and should pertain to the Upper Great Lakes region. Not acceptable are manuscripts of primarily literary nature (including all poetry and articles of an "editorial" orientation). Notes on techniques useful to the teacher and hobbyist are welcomed, as is material of biographical and historical nature.

To promote clarity to non-technical readers (without sacrifice of accuracy and precision), such means are encouraged as illustrations, inclusion of a generally accepted "common name" (when such exists) at least once in the title or text of any article devoted to consideration of one or a few species, and introductory material placing the author's studies in perspective and briefly indicating their significance. Summaries, especially of long or complex papers, are desirable.

Manuscripts should be submitted to the editor in chief and are considered on their botanical merit and clarity of presentation; their acceptability is judged without special regard for repetition of authors, length, or prospect of subsidies. All manuscripts are subject to advisory review by botanists prepared to evaluate not only their content but also their suitability for this journal. Manuscripts are ordinarily published in the order of acceptance, with allowance as necessary for maintenance of diversity within our space limitations. In the interests of diversity, acceptable articles occupying more than 10 printed pages can be published only if divided into two or more issues or if the necessary additional pages can be subsidized (present charge is $12.50 per page). Subsidy of the entire cost of an acceptable article will permit its publication without delay, and authors with access to funds for this purpose are encouraged to allow complete subsidy, regardless of length of article, to avoid contributing toward a backlog of papers awaiting publication.

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An order form for reprints will be supplied when a manuscript is accepted. Reprints (with extraneous matter removed) are supplied at standard prices established by the printer (rate schedule available from the editor).

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Program Notes

April 3-4: Michigan Academy of Science, Arts, & Letters. 74th Annual Meeting, at Wayne State University, Detroit. The speaker at the Biologists Luncheon Friday, April 3, will be David Jenkins, Chief, Research and Development Division, Michigan Department of Natural Resources.

May 29-31: Michigan Botanical Club. Annual Spring Campout, at the University of Michigan Biological Station on Douglas Lake.

The October number (Vol. 8, No. 4) was mailed October 29, 1969.

News of Botanists

DALE HAGENAH has retired from the Chrysler Corporation and is now Research Associate and Curator of the Herbarium at the Cranbrook Institute of Science. . . . Two botanists, both ecologists, have been named provost at their institutions: JOHN E. CANTLON at Michigan State University and RONALD O. KAPP at Alma College. . . . ALEXANDER H. SMITH, Director of the University of Michigan Herbarium, received one of the two Certificates of Merit awarded by the Botanical Society of America at its 1969 annual meeting. . . . WALTER P. NICKELL, who retired in 1968 as naturalist at the Cranbrook Institute of Science, where he was associated for 33 years, has been awarded an honorary membership in the Michigan Botanical Club. . . . GENEVIEVE GILLETTE, President of the Michigan Parks Association and honorary member of the Michigan Botanical Club, was one of four persons (the others were college presidents) recognized as Distinguished Alumni by Michigan State University last June. . . . STANLEY A. CAIN, University of Michigan professor of conservation and former U. S. Assistant Secretary of the Interior, was presented May 23 with the Mary Soper Pope Medal of the Cranbrook Institute of Science for "noteworthy and distinguished accomplishment in the field of plant sciences"; the presentation was made by W. H. Wagner, Jr., a trustee of the Institute, president of the Botanical Club, and Director of the University of Michigan Botanical Gardens. Dr. Cain was the Cranbrook botanist 1946-1950, played an important role in the formation of the Michigan Natural Areas Council, and has served as chairman of the Michigan Conservation Commission.

Publications of Interest

AN INVENTORY OF MINNESOTA LAKES. Bull. 25, Division of Waters, Soils, and Minerals, Minnesota Conservation Department. 1968. 498 pp., plastic binding. This tremendous compilation does for Minnesota much of what "Michigan Lakes and Ponds," reviewed at length in this journal in March, 1966, does for Michigan. For each county, all lakes of 10 acres or more (whether named or not) are listed, assigned a number, located by section(s) and township, the acreage stated. There are additional notes, summaries, and classifications, and a master alphabetical index to all named lakes. A map for each county locates its lakes (but almost nothing else except survey township lines and major towns). In all, 15,291 lakes are tabulated. Unlike the highly restricted Michigan volume, this one is readily available for $4.64 postpaid from Documents Section, 140 Centennial Bldg., St. Paul, Minnesota 55101.

FLOWERS OF EUROPE. By Oleg Polunin. Oxford University Press, London, 1969. 622 pp. + 192 color plates. £4.4s [= $10.08]. Those who are tired of high prices for well illustrated wildflower books will welcome this exceptional bargain which can be obtained for about $10.00 plus postage from any British bookseller (considerably more locally). The plates include over 1000 good color photographs, and in addition 280 species are shown in line drawings. The text keys and describes in detail over 1900 species of the commoner and most attractive seed-bearing plants found in Europe, and almost another thousand are described less fully. Many of them are also found in North America.

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(On the cover: Longitudinal section of a twig of Black Walnut,
Juglans nigra, *showing characteristic chambered pith.*
Photograph by James R. Wells from material gathered July 1968
along Ford Road, Washtenaw County, Michigan.)

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Articles and notes dealing with any phase of botany relating to the Upper Great Lakes Region may be sent to the editor in chief. The attention of authors preparing manuscripts is called to "Information for Authors" (Vol. 9, p. 62; copies available from the editor).

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CHROMOSOME STUDIES OF SOME MOSSES OF THE DOUGLAS LAKE REGION

Jerry A. Snider
Department of Botany, Duke University,
Durham, North Carolina

The moss flora of the Douglas Lake region of northern Michigan has been thoroughly studied during the past 50 years. From the time the first bryology course was taught at the University of Michigan Biological Station by George E. Nichols in 1920 through to the present course taught by Howard A. Crum, a large collection of the mosses occurring in this region has been made. A detailed list of this flora has been published by Crum (1964; 1965), with additions by Miller and Crum (1966) and Crum and Miller (1967). No publications are known which deal with the chromosome numbers of mosses of the area. The present paper reports counts on six species collected in the Douglas Lake region and adjacent counties.

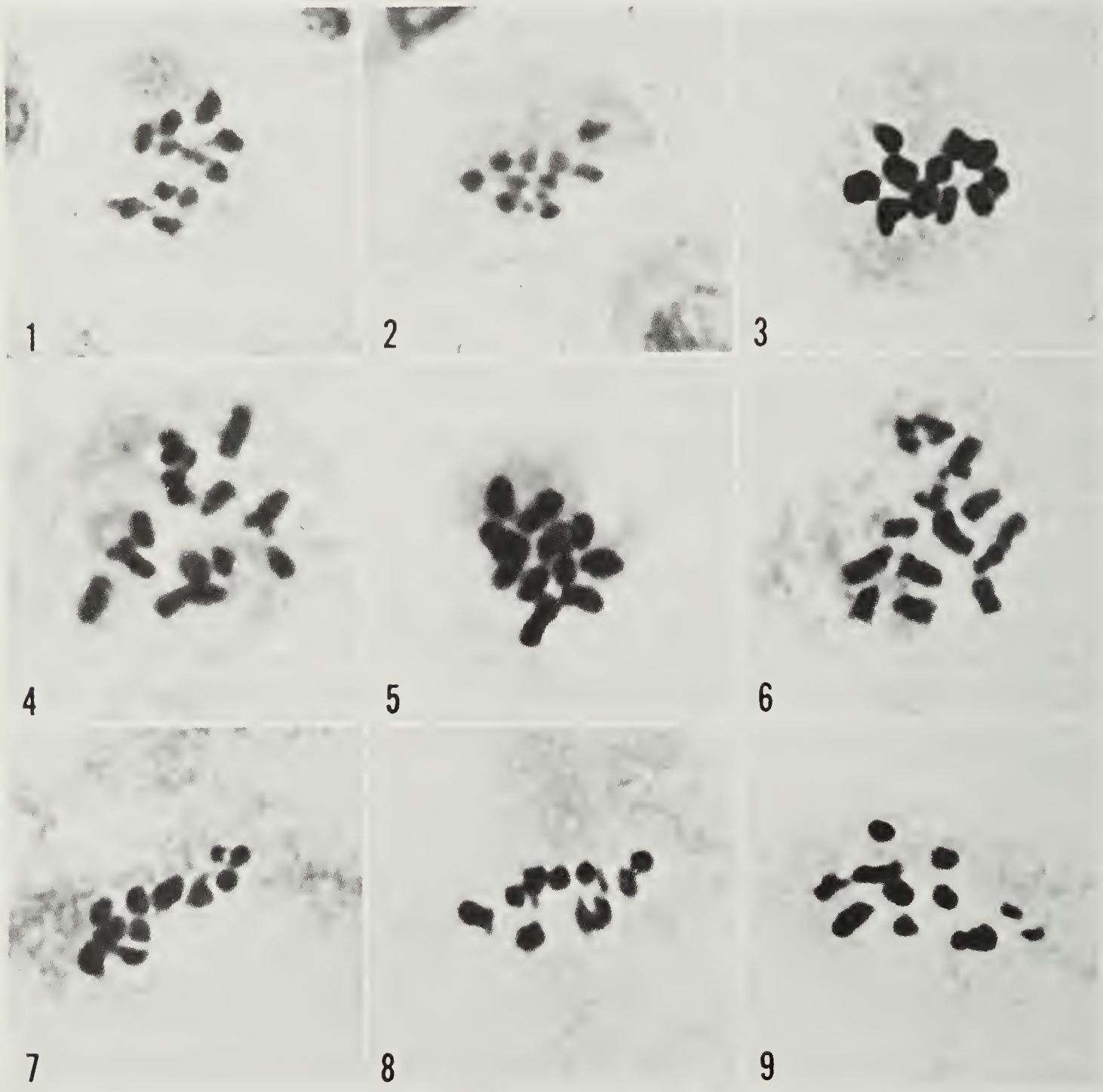
An outline of the techniques used is given to aid those interested in doing further study. For additional accounts of methods and techniques the student is referred to Steere, Anderson, and Bryan (1954) and Anderson and Crum (1958). The method used in this paper is that adopted by Anderson in his numerous investigations of moss cytology.

All cytological studies were made on spore mother cells (SMC) at meiosis. Living plants were collected during July and August, 1969. Immediately upon collection the plants were placed in polyethylene bags to keep them fresh and moist. Plants having well-formed, healthy capsules with a faint yellowish color in the annulus generally proved to be in the proper stages of meiosis. Although this color character did vary from species to species and sometimes even within the same species, it was, nevertheless, an excellent aid to obtaining sporophytes in meiotic condition. In some instances, such as in *Pylaisiella,* the annulus exhibited a translucent to a very faint yellowish color during meiosis, whereas in *Dicranum* the annulus had a definite light yellow aspect to it. The other extreme was observed in species of *Brachythecium* in which a very definite yellow-brown color in the annulus was indicative of meiosis.

The selected capsule was placed on a clean microscope slide, flooded with fixative (3 parts absolute alcohol : 1 part glacial acetic acid) and cleansed thoroughly of dirt, sand, and other debris. The calyptra and operculum were removed by cutting below the annulus. It is important that the capsule and its contents not be allowed to dry out. The spore mother cells were removed by squeezing the columella out or by dissection if the columella refused to slip. When the SMC were freed from the columella, or the sporogenous tissue was dissected out in small pieces, some of the fixative was allowed to evaporate. While the SMC were still slightly moist a drop of aceto-orcein was applied. The cover glass was then gently applied and a slight tapping motion on the surface of the cover slip was initiated to spread out the SMC. Pressure can

then be applied to the cover glass in a variety of ways, including continuous pressure with the slide inverted on absorbent paper, by tapping with various blunt tools, or by a combination of these procedures. Some species require only the lightest pressure while others require very rigorous pounding in order to flatten the SMC. When the SMC were sufficiently flattened the cover glass was sealed with vaseline or other suitable material and the SMC studied immediately. In some instances the chromosomes were slow in absorbing the stain and it was necessary to store the preparation overnight. Finished preparations may be stored from several days to a few weeks by placing the slide in a refrigerator.

Voucher specimens were deposited in herbaria at Duke University, the University of Michigan, and the author's personal herbarium.



Figures 1-9. ca. x2300. Figs. 1-2. *Bryum argenteum,* n = 11. Fig. 3. *Dicranum flagellare,* n = 12. Figs. 4-6. *Dicranum scoparium,* n = 12. Figs. 7-9. *Pylaisiella selwynii,* n = 10 + m.

Bryum argenteum Hedw. n = 11 (figs. 1,2,10,11). On soil in pasture, Magee Rd., Charlevoix Co., Michigan, 31 July 1969, *Snider 894.* Steere, Anderson, and Bryan (1954) reported the number n = 12 for a California population identified as var. *lanatum* BSG. Anderson and Bryan (1958) and Al-Aish and Anderson (1961) reported the number n = 10 for populations of *B. argenteum* from North Carolina. Steere (1954), however, reported the number n = 11 from an arctic Alaskan population of this species, and recognized a large bivalent dissociating early. Although in my counts the early dissociation of a single bivalent was recognized (figs. 2,10), no size difference was noted among the eleven bivalents.

Dicranum flagellare Hedw. n = 12 (figs. 3,12,13). On soil bank of Five-Mile Creek near Lake Michigan, Emmet Co., Michigan, 2 August 1969, *Snider 871.* Five counts were obtained from this population with the number n = 12

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Figures 10-18. ca. x2300. Drawings made from photographic negatives. Figs. 10-11. *Bryum argenteum,* n = 11. Figs. 12-13. *Dicranum flagellare,* n = 12. Fig. 14. *Fissidens cristatus,* n = 12. Figs. 15-16. *Fissidens osmundoides,* n = 12. Figs. 17-18. *Pylaisiella selwynii,* n = 10 + m.

observed in each count. Meiotic behavior was regular and one large bivalent was observed during metaphase I. This count differs from the number n = 23 on Canadian material by Anderson and Bryan (1958), thus contributing evidence that chromosome races exist in this species.

Dicranum scoparium Hedw. n = 12 (figs. 4,5,6). On soil near the mouth of Five-Mile Creek, Emmet Co., Michigan, 2 August 1969, *Snider 889*. Due to the ease of obtaining good meiotic metaphase stages numerous counts were determined from the Michigan population. The number n = 12 agrees with counts reported by Anderson and Bryan (1958) from populations in North Carolina.

Fissidens cristatus Wils. n = 12 (fig. 14). On moist soil along shore of Wycamp Lake, Emmet Co., Michigan, 9 August 1969, *Snider 898*. Anderson and Bryan (1956) reported the number n = 12 + 1 for this species in Nova Scotia, and Al-Aish and Anderson (1960) published the number n = 13 + 2 as occurring in a population from Florida. Thus, the n = 12 count in this report adds still another for this species in North America. One of the larger bivalents disjoins early during metaphase I and could be recognized in all preparations by its distinctive shape. Anderson and Bryan (1956) also recognized this feature in the Nova Scotia population. The presence of an m-chromosome was not observed in any of the Michigan counts.

Fissidens osmundoides Hedw. n = 12 (figs. 15,16). On soil in a burned-over *Larix* bog, Sec. 25, T33N, R6W, west of M75, Charlevoix Co., Michigan, 24 July 1969, *Snider 884*. Chopra (1961) published the number n = 16 from a population in the Great Smoky Mountain National Park in which he recognized four V-shaped chromosomes. In counts from the Michigan population twelve large bivalents were easily recognized, all of a uniform size. Thus, this report adds yet another count to the many differences existing in chromosome numbers within the Section *Serridium*. The presence of intraspecific chromosome races within this group will have to be studied thoroughly before any conclusions as to relationships can be made.

Pylaisiella selwynii Kindb. n = 10 + m (figs. 7,8,9,17,18). On trunk of maple, Five-Mile Creek near Lake Michigan, Emmet Co., Michigan, 2 August 1969, *Snider 863*. Reports by Steere (1954) on arctic Alaskan populations and Anderson and Bryan (1958) on North Carolina specimens agree on the number n = 11, including the presence of an m-chromosome Numerous counts from the Michigan population agree with these, including the precociously disjoining m-chromosome (figs. 7,8,17,18).

ACKNOWLEDGMENTS

I wish to thank Dr. F. K. Sparrow, director, University of Michigan Biological Station and the National Science Foundation (NSF GB-8440) for partial support while conducting this study. Gratitude is also expressed to Dr. Lewis E. Anderson of Duke University and to Dr. Howard A. Crum of the University of Michigan for their critical reading of the manuscript, and to Dr. Crum for his aid in obtaining specimens and verifying the identifications.

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Review

HOW TO KNOW THE LICHENS. By Mason E. Hale. Wm. C. Brown Co., Dubuque. 1969. 226 pp. $3.00 (spiral); $3.75 (cloth).

Here is a lichen key that really works, and it's a bargain too. The elegant illustrations, together with pertinent comments on specific characteristics, comparisons with related species, and distribution maps, make determinations virtually certain. Though exact enough to satisfy even professional lichenologists, the keys can be understood and easily used by the less informed, even to the technical level of a high school student. The introductory pages give a good background of information on morphology and methods of lichen taxonomy, including color and crystalline tests (with valuable photographs of crystals) and chromatography. Students and those who direct the unlimited energies of students will find use for information on such projects of interest as studies of growth rates and lichen synthesis and techniques of dyeing.

It is interesting to note that the author never uses a handlens or dissecting microscope himself, and the characters on which he bases his key are accordingly quite easily observed. The fact that the author knows his field so well adds authority to a seemingly effortless and simplified approach to an esoteric study. The key has been tested by three lichen classes, under the author's careful supervision, including one of my own at the University of Michigan Biological Station. This book provides names for nearly all foliose and fruticose lichens of North America, from the Arctic to the northern boundary of Mexico, excepting a few poorly understood genera, such as *Usnea, Ramalina,* and *Collema,* which are "summarized rather broadly."

—Howard Crum

INVESTIGATIONS IN THE WHITE WATERLILIES (*NYMPHAEA*) OF MICHIGAN[1]

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INTRODUCTION

Distinguishing *Nymphaea odorata* Ait. from *N. tuberosa* Paine has been a problem for botanists for many years. Fassett (1940) recognized that some profess difficulty in differentiating these species. Sculthorpe (1967) refers to the *Nymphaea odorata* complex and to the fact that in *Nymphaea* there are abundant natural hybrids, most of which are sterile. Conard (1916) states

> It seems highly desirable, therefore, that critical studies should be made of the white waterlilies of all the Great Lake region, and the Central States. Every detail mentioned in the table given above should be carefully examined into. Only thus can the taxonomic value and the range of these plants be determined. At present I do not place entire confidence in any of the published names.

A search of the literature reveals that many authors have worked with *Nymphaea* in some detail, particularly in the late 1800's and early 1900's. The most complete summary exists in H. S. Conard's *The Waterlilies,* published in 1905. One must keep in mind that the older literature uses the name *Castalia* for our *Nymphaea,* and *Nymphaea* for today's *Nuphar.*

The diagnostic characters generally used in *Nymphaea,* although many, are sometimes qualitative and thus indistinct. Waterlilies having characteristics of both *N. odorata* and *N. tuberosa* are found in many areas. Because of the difficulty indicated by the above statements–and experienced by me in recognizing and separating the species in the University of Michigan Biological Station area–a survey of the full range of variations in *Nymphaea* in this region was begun in 1964. The initial attempt was simply to analyze the *N. odorata–N. tuberosa* complex as to morphological characters that could be used to separate the species. During the summers of 1965 through 1969, more detailed studies were undertaken, with financial assistance from The University of Michigan Biological Station and the National Science Foundation.

The taxa in the *Nymphaea odorata–N. tuberosa* complex have been differentiated by various characters, many of which are summarized in Table 1. All of these characters were evaluated in addition to the number of peduncle coils when in fruit; presence or absence of petiole or peduncle hairs; aril size; leaf shape; number of air tubes in petiole; acid-base affinity; water depth preference; temperature and/or weather conditions required for opening and closing; and shelter or protection requirements. A checklist was designed to standardize observations.

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[1]Contribution from the Biological Station of The University of Michigan.

TABLE 1. Traditional characters used in differentiating *Nymphaea odorata* and *N. tuberosa*. All characters from Fernald (1950) except those marked with an asterisk (*), from Fassett (1940).

Character	*Nymphaea odorata*	*Nymphaea tuberosa*
1. Number of stamens	36-100	35-106
2. Opening time	Early morning *7:00 a.m.	8:00 a.m. *8:00 a.m.
3. Closing time	None *1:00 p.m.	Early afternoon *3:00 p.m.
4. Petiole	Purple-green to red	Green striped with brown *Usually 4-5 purple streaks
5. Sepal length and/or width	2.8-8 cm x 1-2.5 cm	——
6. Sepal shape	Ovate-lanceolate	——
7. Sepal color	Purple or green *Often purple	Green *Green
8. Number of petals	17-32	17-32
9. Shape of petals	Tapering ovate *Blunt or pointed	Broadly rounded at summit *Often broader than *odorata*, round
10. Stamens	Inner filaments narrower than anthers	Filaments broader than anthers
11. Tubers	Occasionally present, but not strongly constricted at base.	Present, constricted at base, readily detachable.
12. Leaf size	0.5-2.5 dm across *as much as 4 dm wide	0.5-6 dm wide *as much as 4 dm wide
13. Underside of leaf	Usually purple beneath *Often purple	Green, rarely purple *Green
14. Fragrance	Strong *Present	None or faint *No
15. Diameter of open flowers	5-15 cm *Seldom more than 12 cm	1-2.5 cm [error for dm] *Usually larger than *odorata*

METHODS AND OBSERVATIONS

Observations were made at the following locations in northern Michigan and Ontario, Canada:

ALGER COUNTY
Deer Lake

CHEBOYGAN COUNTY
Vincent Lake
Little Lake 16
East Lake
Duck Lake
Duck Marsh
Upper Black River
Black River
Fontinalis Run at Burt Lake
Douglas Lake
Munro Lake
Mullett Lake
Mud Lake (Inverness Tp.)
Black Lake

EMMET COUNTY
Carp (Paradise) Lake
French Lake
Wycamp Lake
Crooked Lake
Hay Lake

MARQUETTE COUNTY (Huron Mountain Club)
- Mountain Lake
- Howe Lake
- Rush Lake
- Pine Lake
- Ives Lake
- Lily Lake

OTSEGO COUNTY
- Lake Manuka

PRESQUE ISLE COUNTY
- Ocqueoc Lake

SCHOOLCRAFT COUNTY
- Cusino (Round) Lake
- Gemini Lake
- Ross Lake

ALGOMA DISTRICT, ONTARIO
- Black Trout Lake

At most locations, 35 mm color reference slides were taken and material collected for herbarium specimens and for analysis in the laboratory while fresh. Care was taken to collect leaves, flowers, and rhizomes from each location. It is almost useless to collect only leaves and flowers without being sure they are arising from the same rhizome. It is also much more significant to look for tubers along the rhizome. Although this is not an easy task, it is not impossible and can usually be accomplished by wading rather than having to dive. The rhizome is usually covered by only 1-2 inches of mud and silt, and can be taken by following a petiole to its base, grasping the rhizome, and

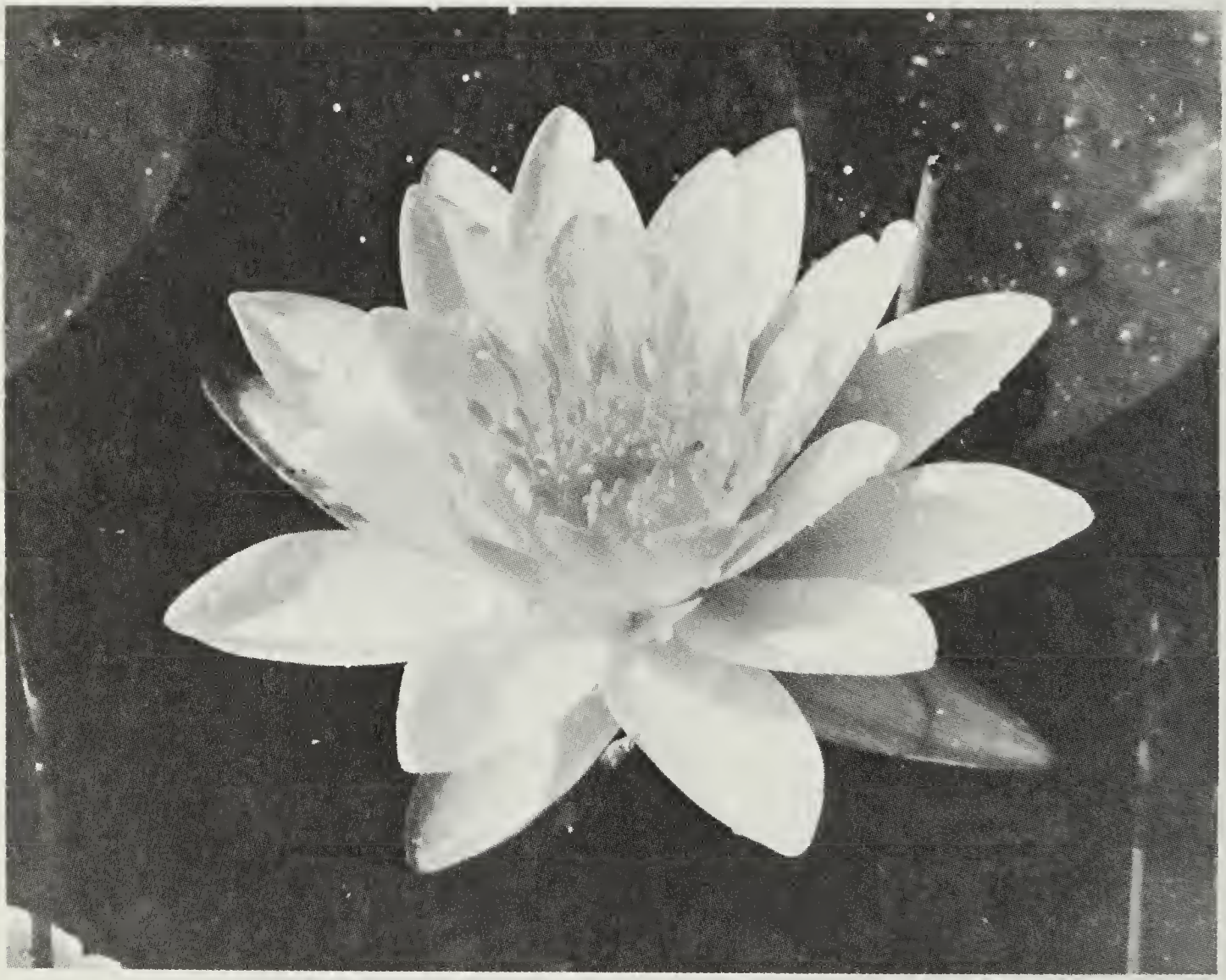

Fig. 1. *Nymphaea* flower photographed August 12, 1969, at Hook Point, Douglas Lake, Michigan.

breaking off a section about 1-2 feet in length. Care should be taken to bring up tubers when present since they break off easily.

Material for chromosome study from root-tips and pollen grains was collected and fixed in Newcomer's solution or 3 : 1 ethanol : acetic acid. Chromosomes were stained with aceto-carmine or aceto-orcein and the squash technique was used. Efforts met with little success due to the very small size of the chromosomes and their high number (2n = 84, Langlet & Söderberg, 1929; 2n = 56, Sculthorpe, 1967). On the average, only about 10-30% of the pollen grains from a single anther were deeply stained. The chromosomes are very difficult to get into a single plane in order to count them. In the few slides which were more or less acceptable, it could only be determined that the chromosome numbers were in the range of 50-70. Not enough data have been collected for this to be helpful information.

The first clone of white waterlilies examined by me was one at Hook Point in Douglas Lake (T37N, R3W, Sec. 22). The flowers (Fig. 1) are fragrant, with narrow inner filaments, and in a size range indicating *Nymphaea odorata.* The leaves are red to purple underneath, with faintly striped petioles, also indicating *N. odorata.* Petal shape, sepal color, presence of distinctly

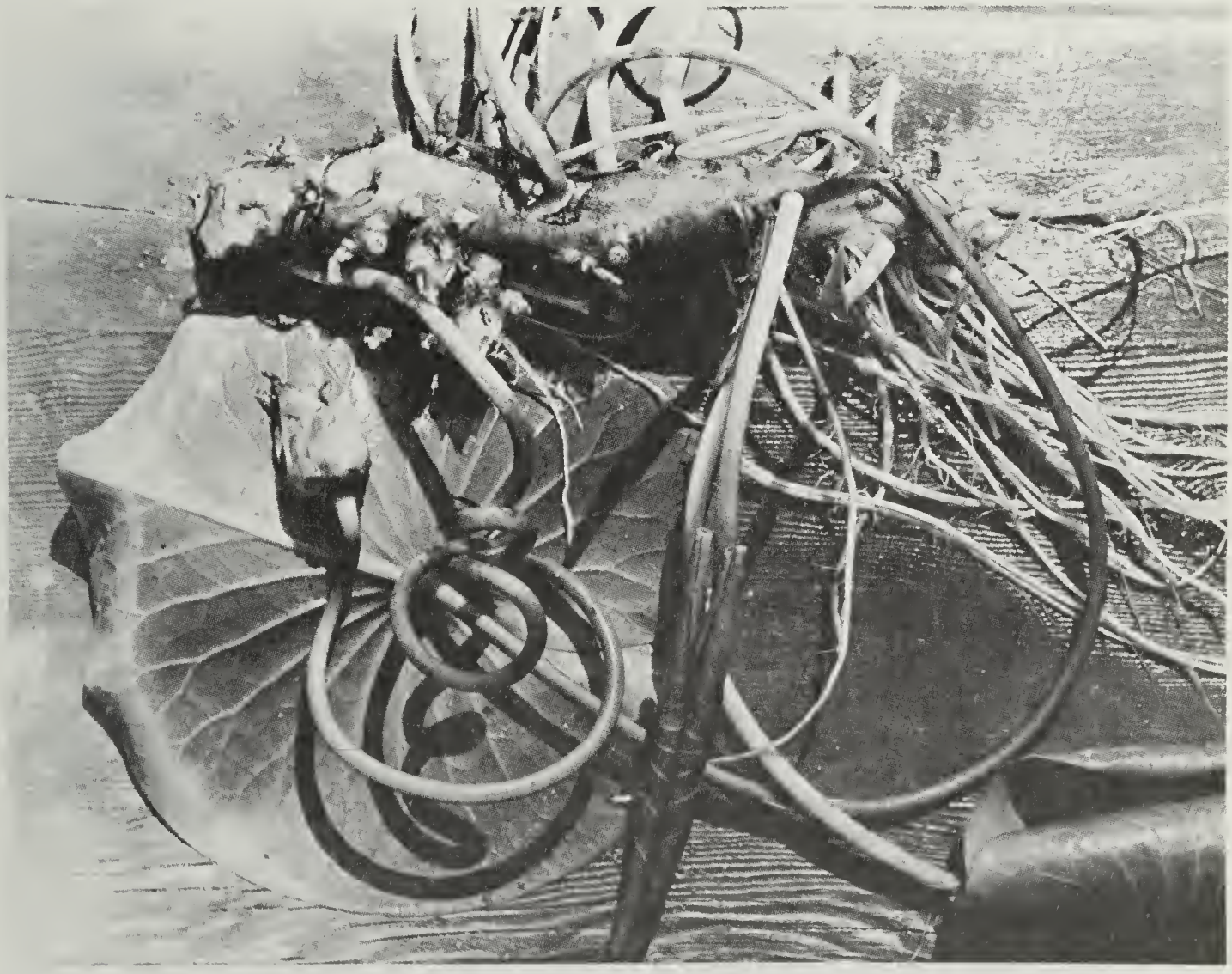

Fig. 2. Rhizome portion collected and photographed August 12, 1969, at Hook Point, Douglas Lake, Michigan. Note coiled peduncle, tubers, and bicolored leaf (actually pink underside with green margin where not in contact with water); cf. Fig. 11.

constricted tubers, petiole and peduncle striping (although faint), and leaves that are green beneath when not in contact with the water all point to *N. tuberosa* (Fig. 2). In retrospect, these plants are nearly perfect intermediates.

The time of opening and closing is widely considered to be diagnostic, with flowers of *Nymphaea odorata* opening about one hour earlier (7:00 a.m.) and closing about two hours earlier (noon or 1:00 p.m.) than those of *N. tuberosa.* After tagging plants at Hook Point in Douglas Lake and at Fontinalis Run, and observing plants in these several lakes, I feel that these characters are not valid. At Hook Point, for example, flowers began to open at 8:30 a.m. and to close at 3:45 p.m. EST. Flowers continued to open throughout the morning and some remained open at 5:05 p.m. Although no tagging was done in the Upper Black River, flowers have been found closed at 11:00 a.m., opening shortly thereafter. Most flowers are still open at 4:30 p.m., but the time of closing has not been observed. At Carp Lake, Mr. Ed Nantais observed a clone of *Nymphaea* at the spillway near his motel during a two-week period in late July and early August, 1964, and reported that the flowers open by 9:00 a.m. and close by 4:00 p.m.

Seeds were collected for study from French Lake and the Upper Black River. These areas were selected because their plants produce abundant seeds and are easily accessible. The plants from French Lake are similar to the

Fig. 3. *Nymphaea* flower photographed July 24, 1969, in French Lake, Michigan.

Nymphaea odorata phenotype (flower in Fig. 3) while those from the Upper Black River are most like *N. tuberosa* (flower in Fig. 4). Seeds were separated by making a cross section through the ovary and squeezing the two halves. The seeds were rinsed several times in tap water, measured, labelled, bottled, and stored in tap water. Approximately half of the seed collected was kept in a four-inch finger bowl at room temperature. The water was changed twice per week. The other half of the seed was kept in a refrigerator at approximately 11° C. The refrigerated seeds were further separated after three months with half of them being put in an aquarium at room temperature and the other half remaining in a refrigerator. Only among the latter did any germination occur. Germination results are summarized in Table 2. Approximately half of the seeds which germinated were placed in dark jars and half of them in an aquarium which was illuminated from 18 inches above by a "Gro-Lux" light. No further growth was noted in any of the seedlings. Figure 5 shows a *Nymphaea* seedling—quite unlike the typical monocot or dicot seedling.

Tetrazoleum, a chemical used extensively to estimate percentage of germination of hybrid seed corn, was tested on *Nymphaea* seeds in the summer of 1967. The powder was mixed with distilled water to make a 1% solution and seeds from French Lake were soaked in it. Ten seeds were cut open each day for eight days. No staining was observed until the third day,

Fig. 4. Upper Black River *Nymphaea.* Photographed August 14, 1969.

TABLE 2. Results of germination tests on *Nymphaea* seeds.

Condition	Seed Source Upper Black River	French Lake	Douglas Lake	Carp Lake
Room temperature	0	0	0	0
11°C for six months	14.4% 31/216	21.4% 48/224	0 0/180	7.4% 11/149
11°C for three months – to room temperature	0	0	0	0

when three seeds had a slightly pink cast in longitudinal section. After eight days, of the ten seeds cut, four displayed some pink to red staining and six showed no staining at all. Further work is being done on cold-treated seeds.

Tubers were collected in all areas studied and some were allowed to sprout in finger bowls in the laboratory (Fig. 6). These tubers sent up leaves for the entire summer, and when they were transferred in September to an aquarium four inches deep, 18 inches from a "Gro-Lux" light, continued to send up leaves until the following July, when they were discarded. This gives some idea of the potential efficiency of tubers as propagules. Sculthorpe (1967) recounts the plowing of a field near Buffalo, New York, that uncovered many *Nymphaea* tubers which when planted in tubs grew into a deep pink variety of *N. odorata.* The land had been drained for many years and a pond had existed there, possibly a century before.

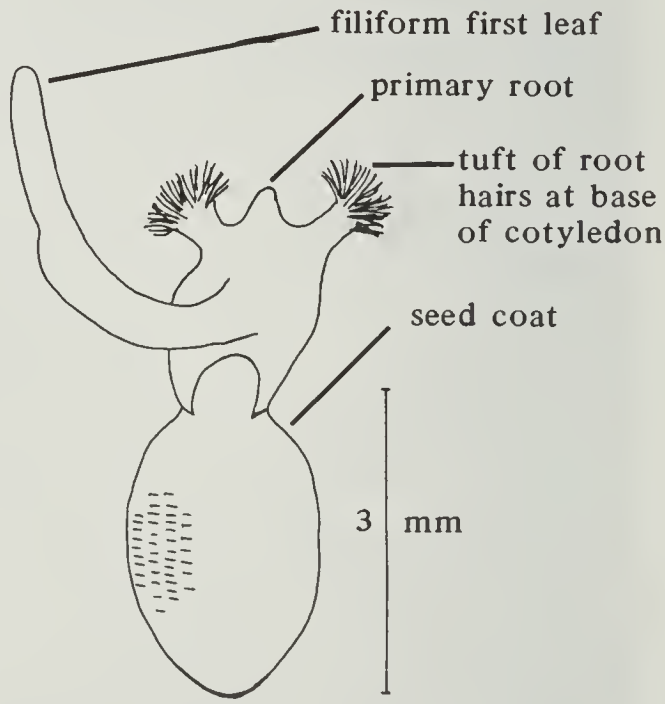

Fig. 5. Germinating *Nymphaea* seedling.

ASSOCIATED ANIMALS

The following macroscopic animals have been observed and/or collected in or on the plants.

BRYOZOA:

Plumatella, Fredericella, and *Hyalinella* on stalks and undersides of leaves.

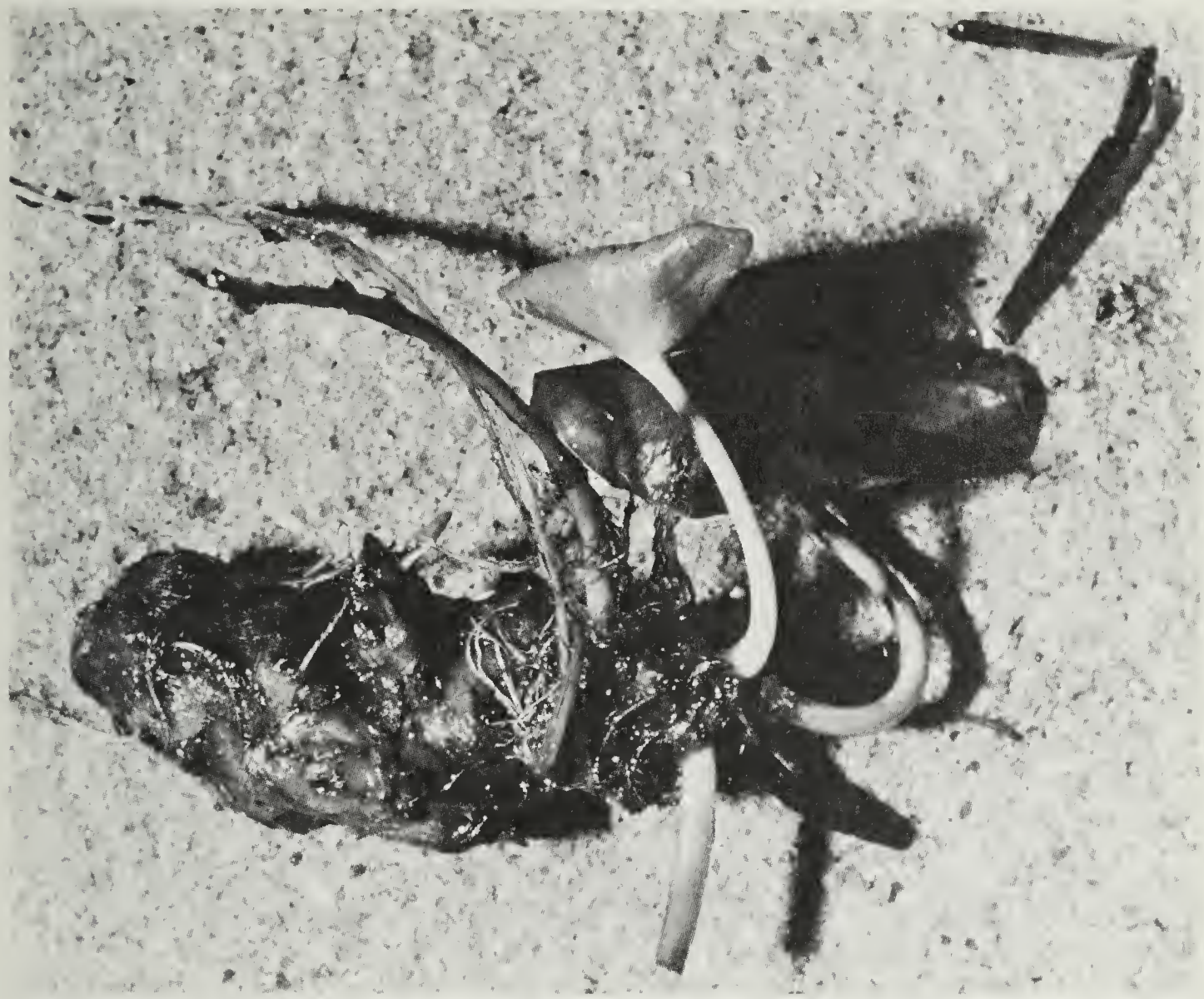

Fig. 6. Tuber, with leaves and roots, collected from Upper Black River, Michigan, August 14, 1969. Actual length was approximately 5 cm.

HIRUDINEA:

Various, particularly *Helobdella, Placobdella,* very common under leaves.

INSECTS:

Odonata larva on stalks.

Homoptera–Aphidae are very common in flowers.

Coleoptera–Chrysomelidae, Curculionidae, Haliplidae, Dytiscidae, and Gyrinidae larvae on stalks and under leaves. Adults in flowers or on leaf tops. Donaciinae adults are the commonest beetles on flowers and leaves. The eggs are apparently laid on the underside of leaves through holes cut in the leaves.

Diptera–many egg rafts are in association with leaves. Some are stuck on the underside of the leaves. Chironomidae larvae are common in the petiole and peduncle air tubes. They are so common in Black Lake and the Upper Black River plants that the appearance of a red "worm" can almost be considered a diagnostic character. *Drosophila* are common in the flower.

HYDRACARINA:

Swimming in near vicinity, sometimes more or less attached to the stalks.

MOLLUSCA:

Various Gastropods quite common on undersides of leaves and on the stalks. *Physa, Bulimnaea, Ferrissia, Stagnicola, Lymnaea,* and *Goniobasis* have been frequently collected.

The above list deserves mention, because some of these organisms probably utilize the leaves and stalks (peduncles and/or petioles) of waterlilies and may cause many of the problems in maintaining transplanted clones. Some of the insects listed above probably aid in the pollination of the flowers. Sculthorpe (1967) indicates that waterlilies are pollinated by beetles, sweat bees, and flies that crawl indiscriminately over the flower. The principal attraction is probably the warmth and smell of the opening flowers and food value of the stamens, since the flowers are nectarless.

TRANSPLANT STUDIES

In the summer of 1965, initial transplants were made in an attempt to discover the effect of the environment on the phenotype of the complex. Additional transplants were made in 1966, 1967, and 1968. Reciprocal transplants were made whenever possible. In a specified pair of lakes, the same location in each lake was used both for collecting and transplanting rhizomes. Two basic methods were used: 1. A rhizome section and soil were put into a 2 × 3 foot box, six inches deep, and the box was weighted with rocks (Fig. 7). 2. A rhizome section was put into a 4 × 12 inch clay drain tile which was partially buried in the substrate (Fig. 8). Any attached leaves were adjusted to allow them to float if possible. Fertilizer when used was a mixture of about ½ dry cow manure and ½ soil, which was moistened, allowed to sit for a few days, and then added to the box or tile near the growing rhizome. The tile method has several advantages: 1. The rhizome is better protected and more stable. 2. It is much easier—no boxes to build. 3. No size-limiting factors are presented as the growing tip of the rhizome can penetrate surrounding substrate. 4. The possibilities of other "unwanted" tubers, seeds, or other propagules washing in is nearly precluded. 5. The tile is more permanent and easier to relocate than the box.

Table 3 summarizes the transplant results. The most interesting transplants are those that "perform" by growing and producing vegetative and reproductive structures. The transplants from Douglas Lake to the Upper Black River, Fontinalis Run to Neu's pond in Glen Ellyn, Illinois, and from the Upper Black River to Cusino Lake are thriving. The July 16, 1966, transplant from Fontinalis Run (apparently a cultivated strain) to Neu's pond produced its characteristic pink-magenta flowers in 1968.

The August 3, 1965, transplant from the Upper Black River to Cusino Lake is unquestionably the healthiest and thus the most valuable for purposes of observation even though the comparatively remote location of Cusino Lake practically precludes frequent observation of the transplant. A brief description of Cusino Lake is given by Voss (1965). On the cover is a photograph of a Cusino Lake flower. As Table 4 indicates, the transplant has each year produced leaves, buds, and presumably flowers (except in 1969), although fully open flowers have not been observed. One can see that a rhizome from a plant with good characters of *Nymphaea tuberosa* produced new leaves each

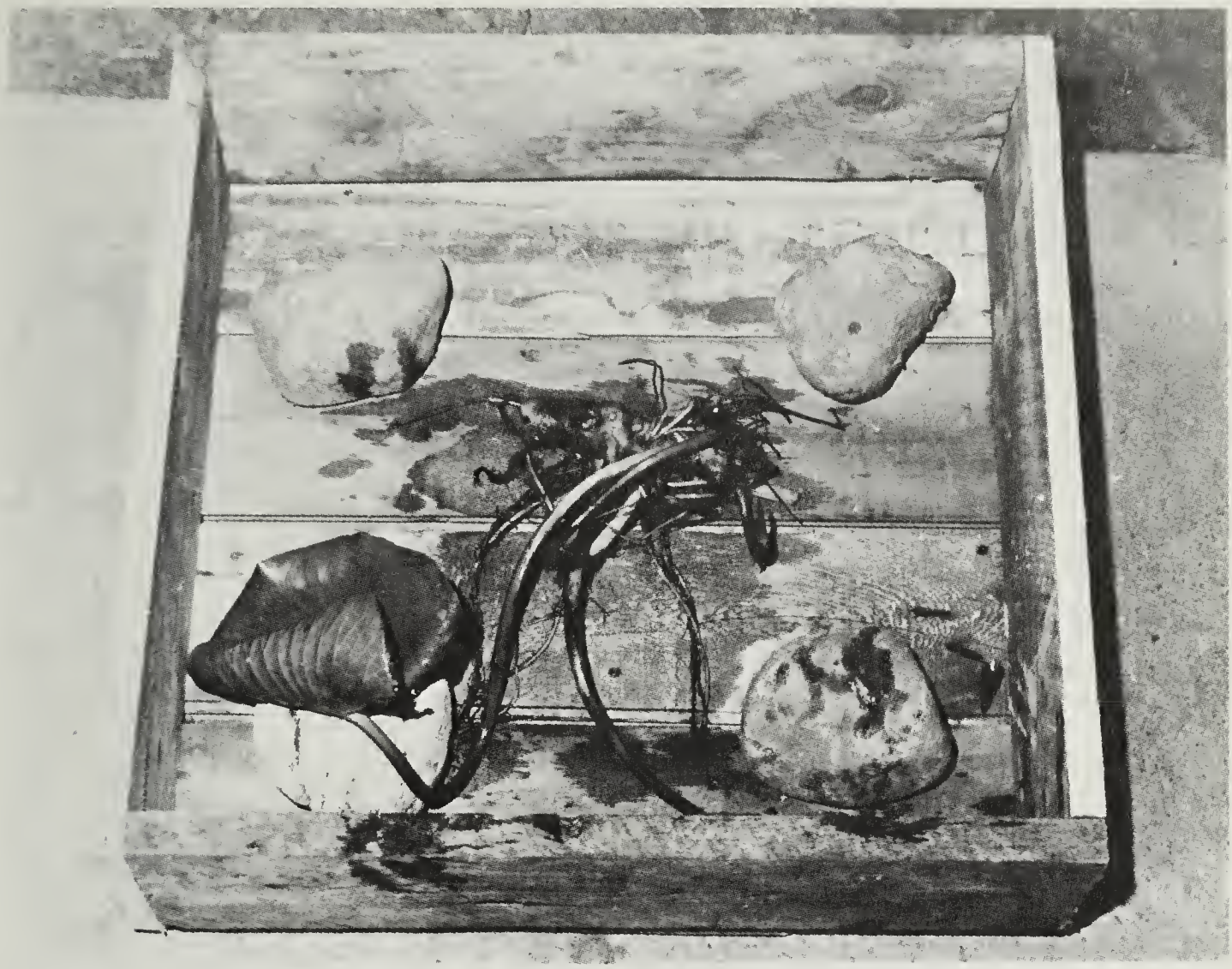

Fig. 7. Rhizome portion of *Nymphaea,* demonstrating the box method of transplanting.

Fig. 8. The tile method of transplanting *Nymphaea* rhizome.

TABLE 3. Summary of *Nymphaea* transplant studies.

Rhizome Source	Transplanted to	Date	Box or Tile F = + fertilizer	Observations* 1966	1967	1968	1969
		1965					
Upper Black River	Cusino Lake	8/3	B - F	1	1	1(Bud)	2
Cusino Lake	Upper Black River	8/5	B - F	3	6	6	6
Upper Black River	Douglas Lake	8/5	B - F	6	6	6	6
Fontinalis Run	Douglas Lake	8/5	B - F	6	6	6	6
Upper Black River	Duck Lake	8/6	B - F	6	6	6	6
Mud Lake Bog	French Lake	8/6	B - F	3	4	6	6
Upper Black River	Lancaster Lake	8/9	B	6	6	6	6
Upper Black River	French Lake	8/10	B	4	6	6	6
Duck Marsh	French Lake	8/10	B	3	6	6	6
French Lake	Upper Black River	8/13	B	2	2	2	2
Duck Lake	Upper Black River	8/13	B	5	6	6	6
Douglas Lake	Upper Black River	8/13	B	5	6	6	6
		1966					
French Lake	Upper Black River	7/1	T - F		3	6	6
Upper Black Lake	French Lake	7/1	T		4	6	6
Lancaster Lake	French Lake	7/8	T		4	6	6
East Lake	Upper Black River	7/8	T		6	6	6
Carp & Black Lakes, Fontinalis Run	Pool at Ed Neu's Glen Ellyn, Illinois	7/16	B		2	1	2
Carp Lake	Upper Black River	7/27	T - F		4	6	6
Upper Black River	Cusino Lake	7/29	T		4	6	6
Cusino Lake	Upper Black River	8/2	T - F		4	6	6
Duck Marsh	Upper Black River	8/9	T		3	6	6
Duck Marsh	Black Lake Bay	8/9	T		5-2	5-2	5-2
Black Lake	Duck Marsh	8/9	T		2	2	2
Upper Black River	Duck Marsh	8/9	T		6	2	2
Canada & Duck Marsh	St. John's College Santa Fe, New Mexico	8/16	B		2	2	4
Duck Marsh & Black Lake	Lake Ellyn, Illinois	8/24	T		2	2	2
		1967					
Douglas Lake	Upper Black River	6/28	T - F			1	2
Upper Black River	Carp Lake	7/1	T			2	2
Carp Lake	French Lake	7/7	T			6	6
Duck Marsh	Upper Black River	7/13	T - F			4	6
Upper Black River	Douglas Lake	7/19	T			6	6
		1968					
Carp Lake	French Lake	7/19	T - F				2
Douglas Lake	Upper Black River	7/26	T - F				2

*KEY: 1 = Survived and flowered; 2 = Survived, produced vegetative parts; 3 = Survived, produced small purple juvenile floating leaves, but died during the summer; 4 = Died during the winter; 5 = Washed out of position; 6 = Transplant could not be found.

TABLE 4. Summary of Upper Black River–Cusino Lake *Nymphaea* transplant.

Character	Native Cusino Lake Plants	Transplant from Upper Black River					
		8/3/65	7/29/66	8/19/66	7/21/67	7/31/68	7/30/69
Leaf diameter (mm)	145	180	135	130	115-120	110-135	115-120
Leaf shape*	2 & 3	1	1	1	1	1 (2)	1
Petiole diameter (mm)	4	6	4	3-4	3	3-4	3
Petiole stripes	0	+	0	0	0	+	0
Leaf color, upper	Green	G	G	G	G	G	G
Leaf color, underside	Red	G	R-Pink	R-Pink	R-Pink	G(Pink)	R-Purple
Leaves, number of		4	12	12	7	5	22
Buds		2	1	3	3	2	0

*Leaf shapes: 1 = 2 = 3 =

year which have been smaller and more purple on the average than those of the original plant. The petioles have tended to be smaller, less distinctly striped, and pinker. In other words, they tend to be more and more like the Cusino phenotype (*N. odorata*?) and less like that of the Upper Black River. The color change in the undersurface of the leaves is most dramatic (Fig. 9). This would lead one to the conclusion that the phenotypic differences in the *Nymphaea* of the Upper Black River and Cusino Lake are dictated largely by the environmental factors and less by genotypic factors. In 1967, the color of the underside of the leaves of the transplant was *green* with only a slight touch of pink on some of them. This would seem to be a reversion to the "parental" phenotype. I interpret this condition to be a reaction to increased water depth with assumed attendant change in average temperature, pH, light penetration, etc. Unfortunately, the reciprocal transplant from Cusino Lake to the Upper Black River did not survive; the leaves were riddled with holes by an unknown predator and it did not produce leaves after 1966.

DISCUSSION AND CONCLUSIONS

Most of the characters listed earlier in this report–such as leaf color, flower odor, and tuber production–are not sufficient to differentiate two species of waterlilies in the Douglas Lake area, although there are certainly distinct differences in the plants from the various lakes studied. Pink-tinted outer petals in the East Lake clone; a distinctive green wedge on the underside of the Cusino Lake leaves (Fig. 9), and leaves with upturned edges from the Black River make these clones identifiable to most observers. Duck Marsh plants have leaves with three and five petiole tubes as well as the usual four (Fig. 10).

The color of the underside of the leaf, long considered to be a good diagnostic character, is apparently not valid–at least in this area. The dramatic

color change in the transplanted material in Cusino Lake attests to this fact. The somewhat less striking changes in the transplants from Douglas Lake to the Upper Black River and others also bear this out. The transplant in each case develops red or pink undersides of the leaves if green initially, or lighter red undersides, if red or purple originally. Juvenile leaves tend to be red or brown and much smaller than the mature leaves. Another interesting fact is that in cases where leaves are held up out of the water, the underside will be green, even though floating leaves on the same plant are red underneath. One leaf collected (*Williams 76*) at Hook Point was floating and in contact with the water over 80 per cent of its undersurface and about 20 per cent of the edge was held out of the water by adjacent vegetation. This leaf was red where in contact with water and green where exposed (Fig. 11). The implication here is that red pigment is produced in response to water contact or its production is inhibited by exposure to air and/or sunlight.

Odor is not a good character to distinguish our taxa, since nearly all flowers tested were fragrant on the first day of opening. Admittedly, however, some were more fragrant than others.

Tubers were found in all areas where collections were made. Some rhizomes had more tubers per foot than others and some were more con-

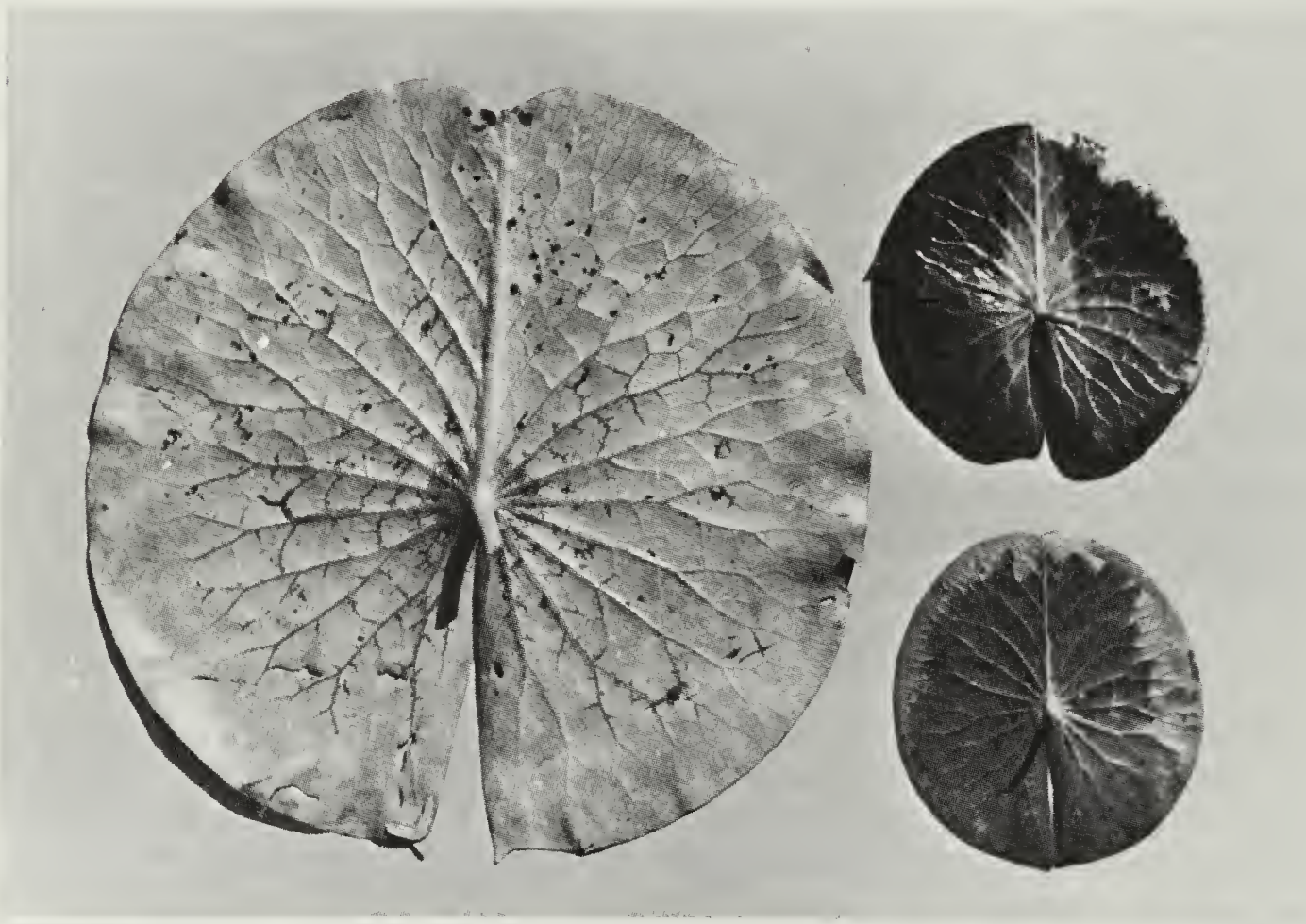

Fig. 9. Undersides of 3 *Nymphaea* leaves. At the left is a 25 cm diameter leaf from Upper Black River, August 14, 1969. At the upper right is an 11 cm leaf from Cusino Lake. The one on the lower right is a 10 cm leaf taken from the transplant from Upper Black River to Cusino. Both Cusino specimens were collected August 15, 1969. Note the lighter (green) color of the Upper Black River leaf and the darker (red-purple) color of the other two. The Cusino leaf displays a lighter (green) wedge running along the midrib. The distinctive shape of the leaf apexes is also shown.

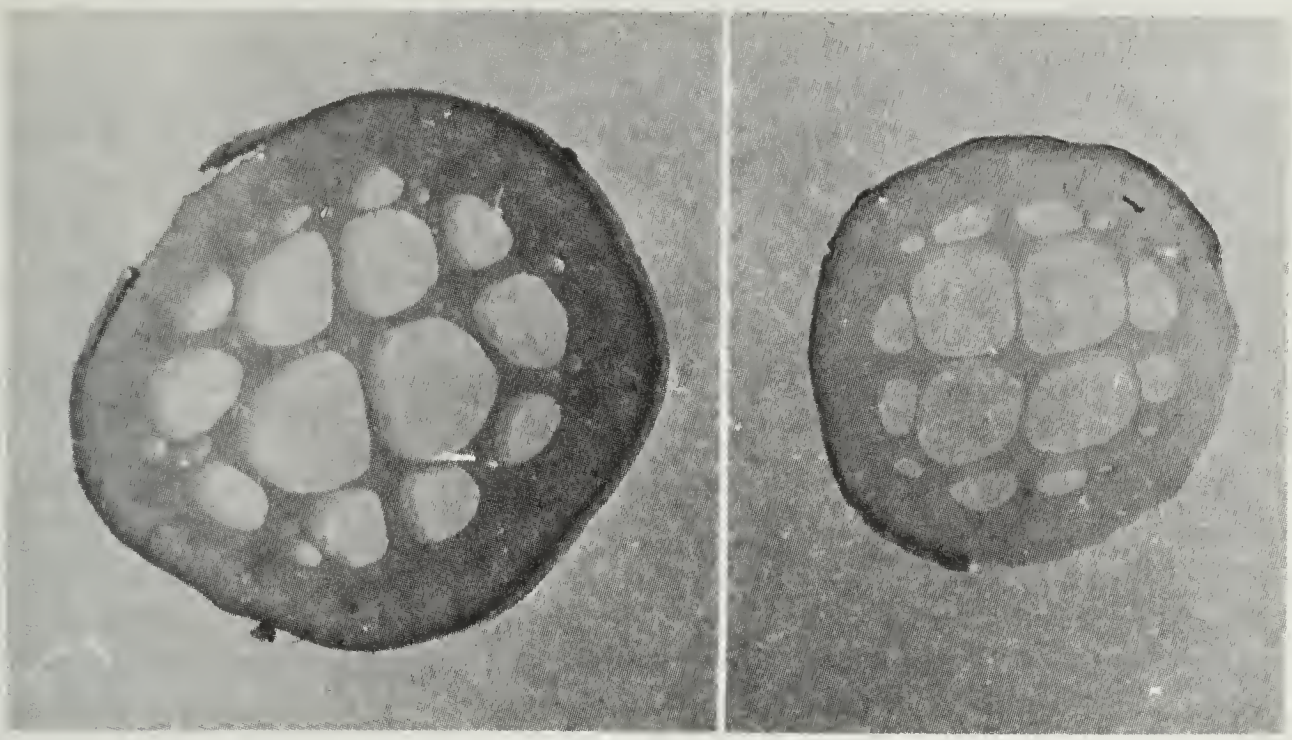

Fig. 10. Cross-sections of *Nymphaea* petioles from Upper Black River (left) and Cusino Lake (right). The larger petiole measured 6 mm in diameter. Note that both have 4 major petiole tubes although the former has 2 large and 2 small tubes while all 4 tubes are more or less equal in the latter.

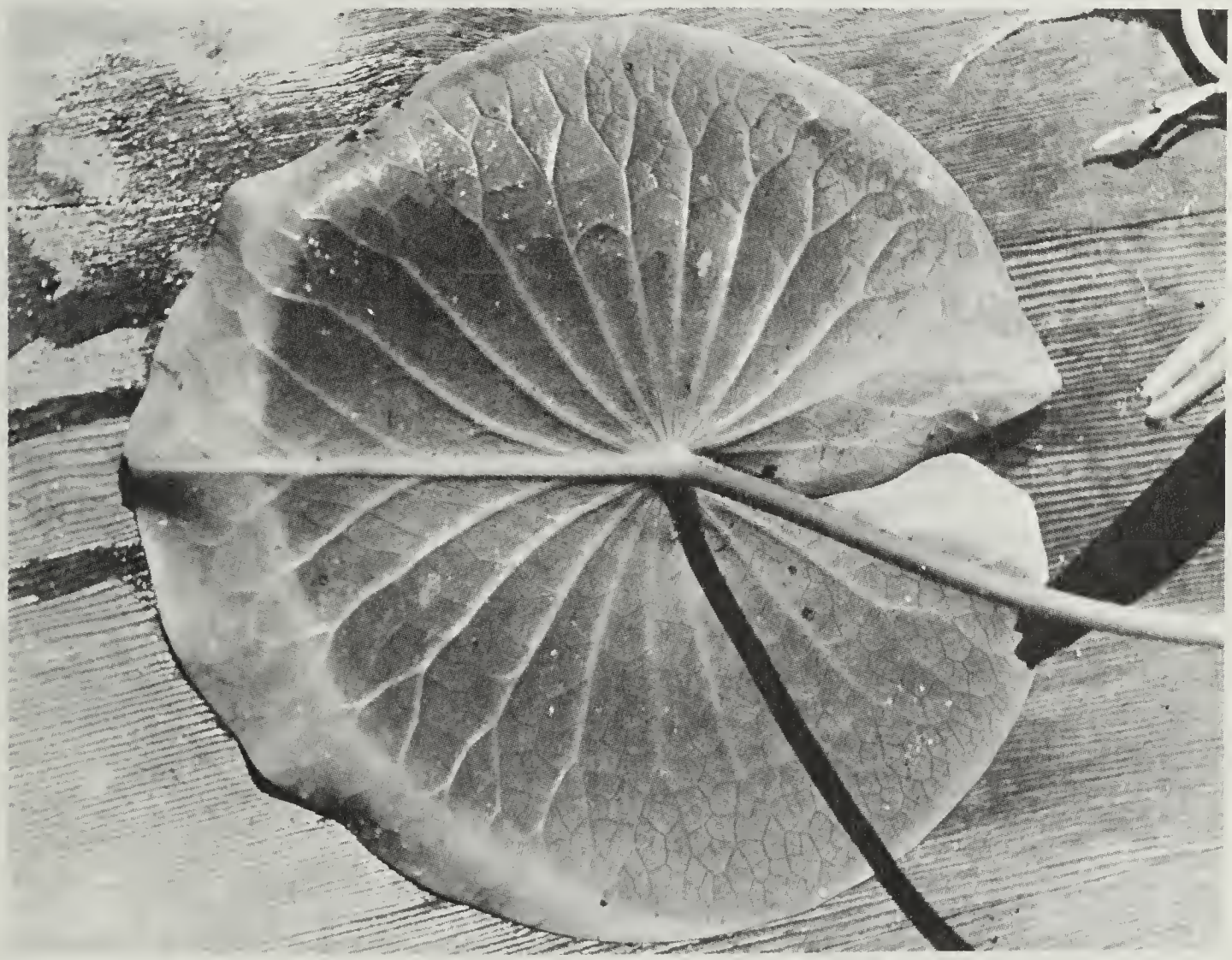

Fig. 11. Bicolored leaf collected August 12, 1969 at Hook Point, Douglas Lake, Michigan. The lighter (green) margin at the apex and sinus was not in contact with the water while the darker (red-purple) portion was floating on the water's surface. Actual diameter was 17 cm.

stricted at the base than others, but tubers were always present (Fig. 2).

The peduncles coil and pull the fruit under the surface of the water after the flower is fertilized. This characteristic is well displayed in French and Douglas Lakes, but the number of coils is not constant even in flowers growing from the same rhizome (Fig. 2).

I do not believe that hybridization is an important factor because of a lack of evidence of reproduction by seeds. In the six-summer period, only one seedling was discovered that could definitely be identified as *Nymphaea*. *Nuphar* seedlings are quite common and could be confused with *Nymphaea* at first glance. The lack of good staining points to abortive or sterile pollen. The size and color difference in seeds and ovules indicates that many, perhaps most, of the ovules are not fertilized. In many mature ovaries are found mostly yellow seeds 1 mm long and only a few red to brown seeds 3-4 mm long. From tetrazoleum and germination tests, apparently only the larger ones are viable seeds. Most reproduction is by tubers breaking off and floating away to become lodged and rooted elsewhere (Fig. 6). Germinating tubers can be readily found in nearly any of the lakes examined. The leaves from tubers can be identified by their small size (about 15 × 20 mm) and uniform brown-red color throughout.

The white waterlilies in the Douglas Lake area are a highly variable taxon and there seems to be no good reason for calling them distinct species. They are most certainly a single species or very closely related species that are showing variable responses to their environments.

ACKNOWLEDGMENTS

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ADDITIONAL BRYOPHYTES FROM SINKHOLES IN ALPENA COUNTY, MICHIGAN, INCLUDING *ORTHOTRICHUM PALLENS* NEW TO EASTERN NORTH AMERICA[1]

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One of the results of our field work in northern Michigan during the summer of 1968 was extensive collecting in several limestone sinks located in northern Alpena County. Many interesting and rare ferns were reported from these sinks by Hagenah (1955). He listed *Matteuccia pensylvanica* (Willd.) Raymond, *Cystopteris fragilis* (L.) Bernh., *C. bulbifera* (L.) Bernh., *Dryopteris spinulosa* (O.F. Müll.) Watt, *D. filix-mas* (L.) Schott, *Athyrium pycnocarpon* (Spreng.) Tidestr., *A. thelypterioides* (Michx.) Desv., *Asplenium trichomanes* L., and *Polypodium virginianum* L. Wagner and Lord (1956) reported *Botrychium lunaria* forma *onondagense* (Underw.) Butters & Abbe, along with *Cystopteris dickieana* Sim, from a sink near Bolton, noting that this was the only locality for this form of *Botrychium* in the Biological Station region. Robinson and Wells (1956) studied the bryophyte flora of the sinks and published a list of 110 species including three new to Michigan: *Seligeria calcarea* (Hedw.) B.S.G., *Mannia siberica* (K. Müll.) Frye & Clark, and *Tritomaria scitula* (Tayl.) Joerg.

After several collecting trips to the sinkholes, we can add the moss *Orthotrichum pallens* as new to eastern North America and several noteworthy records of rare or infrequently collected hepatics.

THE SINKHOLE AREA

The sinks at the four sites studied by Robinson and Wells (1956) occur across a distance of 10 miles in north-central Alpena County from just north of Long Rapids east to Cathro. All have developed in the Middle Devonian Alpena limestone and judging from their small size and relatively uneroded sidewalls, which show no evidence of glacial abrasion, the sinkholes appear to be postglacial in origin. During the summer of 1968, either jointly or independently, we revisited all of the sinks originally studied by these workers. However, because our collections from "Bolton Sink" and the "Four Sinks" are most noteworthy, this report will treat only these two localities.

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Bolton Sink is unquestionably the most interesting sink in the region. It is located about 2 miles southeast of Bolton near the center of the northern half of Section 14 (T. 32 N., R. 7 E.)[3] and is the only one we visited with an extensive talus slope and persistent ice deposits. The sink is best reached by walking south from Daggett Road. Open fields, thin secondary forests and low limestone outcrops occur around the sink and the surrounding land is decidedly dry. At most places flat-lying limestone bedrock appears to be less than a meter below the surface. The sink itself is small, about 200 meters in diameter and 25 meters deep. The east and part of the north side are bare and mostly covered by a talus of loose boulders. A dense growth of *Thuja occidentalis* occurs on other slopes and limited exposures of bedrock are found just below the rim at various locations but particularly on the south side. The more or less flat bottom, scarcely 10 m across, is mostly shaded and covered by a jumble of large and small boulders. The talus slopes above the bottom are fairly steep but stable where tree-covered and in total aspect the sinkhole is funnel-shaped.

It is evident that the talus is largely man-made, for it is a mixture of native limestone rock and glacier transported igneous and metamorphic boulders. Local farmers undoubtedly found the sink a convenient dump for the numerous bothersome rocks that cluttered their fields. Through the years the talus slopes were gradually built, first slowly by limestone blocks that broke off the sidewalls and fell into the hole and later, after the settlement of the region, more rapidly by European man who added many tons of field stones. The massive rock piles seen frequently in northern Alpena County attest the former abundance of rock in the soil. In contrast to several nearby sinks very little trash has been thrown into Bolton Sink. However, charred stumps and logs are an indication that fire has swept the site at least once.

Ice is found well into the summer near the bottom in spaces between boulders and may persist year round if the summer months are especially cool and dry. Robinson and Wells report seeing ice as late as June 26 during 1955 and we observed a large mass of ice near the bottom at the north side on 4 August 1968. However, somewhat later in August of the following year none was visible even though the air temperature was much lower at the bottom of the sink than at the rim (M. Frohlich, pers. comm.). The luxuriant growth of *Drepanocladus uncinatus, Hylocomium splendens, Marchantia polymorpha* var. *aquatica,* and *Tritomaria scitula* is evidence that the cool humid environment at the bottom of Bolton Sink, in contrast to the more xeric surrounding region, is especially favorable to the growth of bryophytes.

The Four Sinks are located 2 miles southeast of Leer in the NW ¼ of Section 16 (T. 32 N., R. 6 E.). They occur in a woodlot and for the most part are wooded themselves. Three of the sinks have extensive areas of exposed limestone sidewalls and are considerably larger than the sink near Bolton. Talus is mostly absent and the best bryophyte habitats are on ledges

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[3]Robinson and Wells located Bolton Sink in the NW ¼ of Section 12 (T. 32 N., R. 7 E.), but after first searching this quarter-section and later writing to them, we are certain that the correct location is Section 14.

and in crevices of the limestone, as well as on moist decorticated logs found at the bottom of the sinks. The collections we record here were made at the third and fourth sinks in from Leer Road.

ORTHOTRICHUM PALLENS

Orthotrichum pallens Bruch ex Brid., Bryol. Univ. 1: 788. 1827.

Orthotrichum pallens var. *typicum* Vent., Hedwigia 12: 20. 1873. *nom. illeg.*

Dorcadion pallens (Bruch ex Brid.) Lindb., Musci Scand. 28. 1879.

Orthotrichum pallens var. *commune* Vent. in Husn., Musc. Gall. 189. 1887.

Orthotrichum pallens var. *saxicola* Burch., Hedwigia 31: 30. 1892.

Orthotrichum pallens ssp. *eu-pallens* Giac., Atti Ist. Bot. Pavia V. 4: 248. 1947. *nom. illeg.*

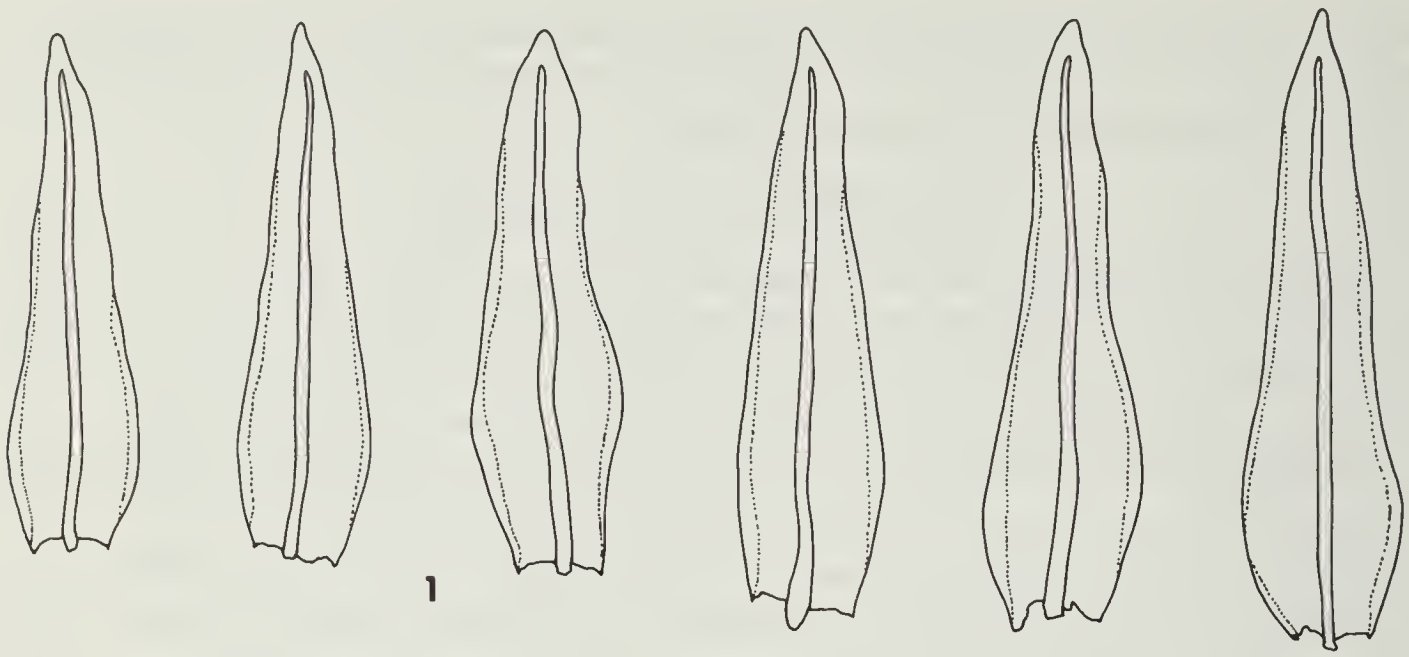
Plants 3-10 mm high, in yellow-green, olive-green, or dark brown, dense to loose tufts. Leaves loosely erect-appressed and slightly incurved when dry, erect-spreading to spreading when moist, 1.6-3.0 mm long, oblong-lanceolate to lanceolate, narrowly obtuse to broadly acute; margins entire, recurved-revolute to near apex; costa slender, ending near the apex; upper cells 9-14 μ wide, irregularly rounded to rounded-hexagonal, thick-walled, with 2(3) low, conical papillae; basal cells rectangular, hyaline, grading to quadrate at margins; broad bodies sometimes present on leaves. Cladautoecious. Setae 0.5-1.5 mm long; capsules 1.3-2.25 mm long, emergent to barely exserted, oblong-cylindric, strongly 8-ribbed and becoming narrowly cylindric and contracted along the entire length when old, contracted to the setae through a ± short neck, exothecial cells differentiated into bands 4-6 cells wide; stomata immersed in 1 or 2 rows at the middle of the capsule, scarcely or not covered by the poorly differentiated subsidiary cells, the inner walls not or scarcely thickened; peristome double; exostome teeth 8, evenly and densely papillose, erect until old, then reflexed; endostome segments 16, rarely 8 of these rudimentary or lacking, about as long as exostome, incurved and conspicuous, smooth or finely papillose, margins sometimes crenulate, of one or two rows of cells. Spores 11-17 μ, coarsely papillose. Calyptrae conic-mitrate, plicate, naked, smooth or slightly papillose on plications. Figures 1-8.

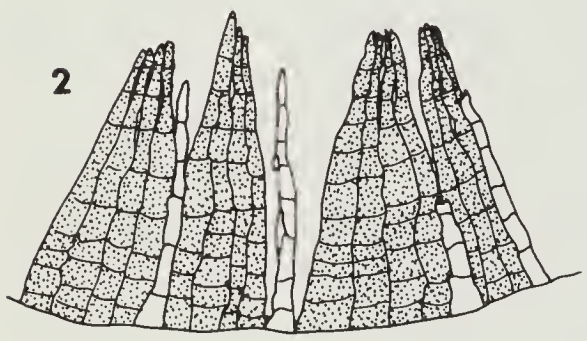
Habitat: On the trunks of trees or on tree branches and on dry rocks, usually calcareous or granitic.

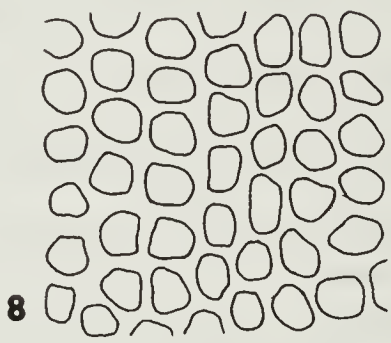
Distribution: Europe—Austria, Germany, Switzerland, Scandinavia, Italy, France, Russia; North America—see Figure 9.

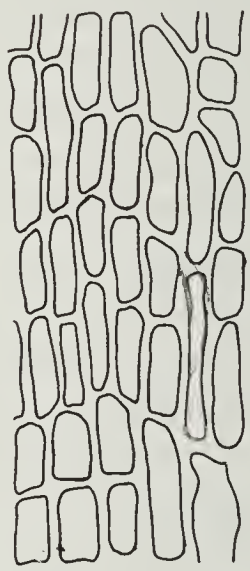
Specimens Examined from Eastern North America: CANADA—Quebec. Gaspé Peninsula, Percé, *Stifler,* July 1938, ex herb. Grout (DUKE). U.S.A.—Michigan. Alpena Co., Bolton Sink, on *Thuja* branches, *Vitt 886, 887* (MICH), *Miller 4913, 4914;* on limestone boulder, *Vitt 888, Robinson & Wells,* June 26, 1955 (MICH). Keweenaw Co., Fort Wilkins, *Sharp,* Sept. 1, 1937 (TENN).

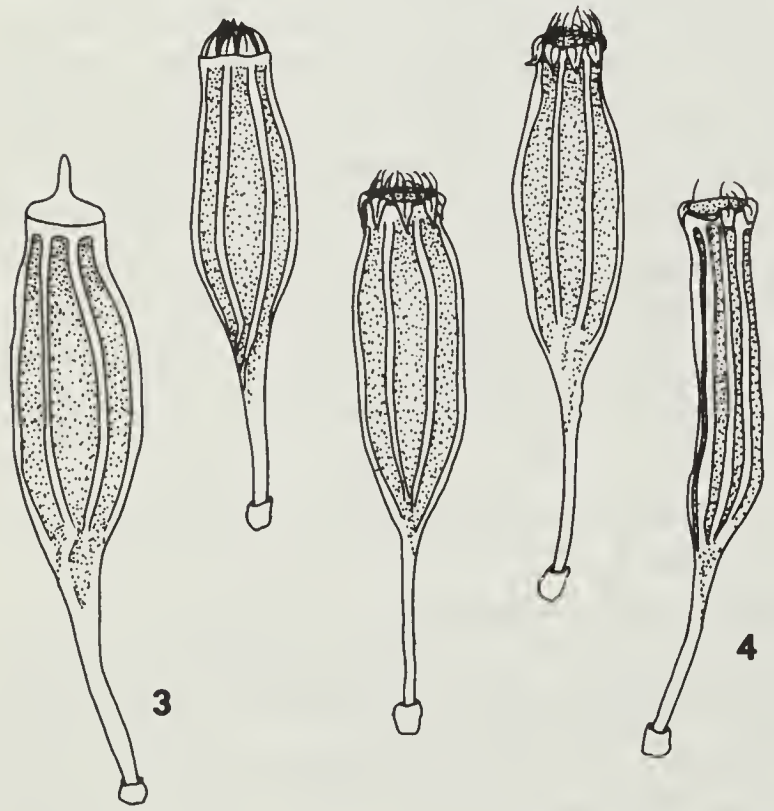
Discussion: Orthotrichum pallens is distinguished by having immersed stomata which are scarcely covered by thin-walled subsidiary cells over the spore-bearing portion of the capsule. The peristome is double with a well











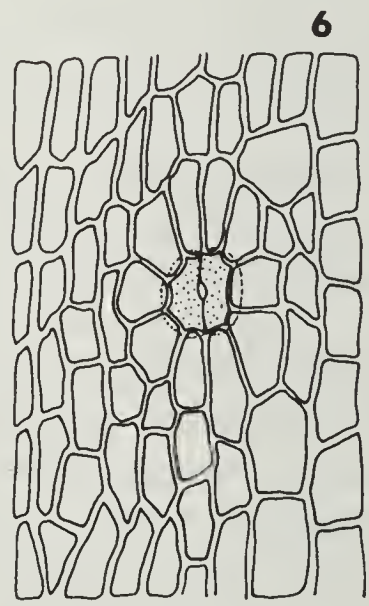


Fig. 1-8. *Orthotrichum pallens* Bruch ex Brid.: 1. Leaves, x 33. 2. Peristome from inside, x 108. 3. Mature capsules, x 19. 4. Old and dry capsule, x 19. 5. Calyptra, x 19. 6. Stoma, x 177. 7. Basal leaf cells, x 306. 8. Upper leaf cells x 306.

developed endostome of 16 segments which remain intact until the capsule is quite old. Gametophytically, the species is distinguished by having narrowly obtuse, oblong-lanceolate leaves. The basal leaf cells are thin-walled and rectangular. The plants are cladautoecious, that is, the perigonia are at the ends of separate branches instead of in the usual axillary position. No other North American species in the Orthotrichaceae has an endostome of 16 segments and stomata which are scarcely covered by the subsidiary cells.

The specimens examined from the sink area as well as those from the Gaspé Peninsula have capsules which are almost exserted. These specimens are identical with the European *Orthotrichum pallens* var. *saxicola* Burch. However, after studying both European and North American specimens, we have decided that this and other characters are variable and do not correlate with each other. Thus the var. *saxicola* has been relegated to synonomy.

In western North America there exist two forms closely allied to typical *Orthotrichum pallens.* These western plants are characterized by being smaller and having shorter, oblong capsules with a very short seta. These forms have been referred to variously—and apparently incorrectly—as *O. pallens, O. pallens* var. *parvum* Vent., and *O. microcarpum* De Not. This problem will be dealt with in detail in a separate paper in preparation by the junior author.

Orthotrichum pallens, in a broad sense, is distributed in a discontinuous pattern in boreal and alpine regions over much of the Northern Hemisphere.

Fig. 9. Distribution of *Orthotrichum pallens* Bruch ex Brid. in North America, based on specimens examined. (Goode Base Map No. 102, copyright by the University of Chicago, used by permission.)

In North America the geographic range of this species is broken up into the following disjunct areas: (1) scattered in the western Cordillera, (2) northern Michigan including the Keweenaw Peninsula, (3) the Gaspé Peninsula in Quebec, and (4) Cerro Potosi in northeastern Mexico. The latter is the southernmost station for the species and represents the only report from Mexico (Delgadillo & Vitt, 1970).

Fernald (1935) pointed out that the Keweenaw Peninsula as well as the Gaspé Peninsula contains a well-marked Cordilleran element in the vascular plant flora. Similarly, Steere (1937) found among the bryophytes of the Keweenaw Peninsula a distinct Rocky Mountain element. He mentioned among others *Timmia austriaca* Hedw., *Frullania bolanderi* Aust., and *Jungermannia schiffneri* (Loitlesb.) Evs. The distribution of *Orthotrichum pallens* parallels that of these species (see Fig. 9).

It should be noted that the entire sinkhole region was glaciated in Wisconsin times and the sinkholes under discussion here presumably originated after glaciation. Therefore, the occurrence of *O. pallens* in these sinks seems clearly to be a result of postglacial migration. If the Cordillera served as a plant refuge during Pleistocene glaciation, then *O. pallens* is an example of a species which has migrated eastward following disappearance of glacial ice.

ADDITIONAL SPECIES NEW TO THE SINKS

To the species listed by Robinson and Wells (1956), we can add the following as being found at Bolton or Four Sinks. Specimens cited below are deposited in the University of Michigan Herbarium (MICH), the University of Michigan Biological Station Herbarium (UMBS), or the private collection of Norton G. Miller. A total of 101 species of mosses and 24 species of hepatics are now known from the entire sinkhole region.

Musci

Fissidens minutulus Sull. Four Sinks: On dry limy lithosol, limestone ledge, third sink in from road, *Miller 4602* (UMBS).

Ditrichum flexicaule (Schwaegr.) Hampe Bolton Sink: On moist side of boulder near sinkhole floor, *Miller 4595* (UMBS).

Seligeria campylopoda Kindb. ex Mac. & Kindb. Bolton Sink: On limestone boulder beneath *Thuja,* S side, *Miller 4920* (with *S. doniana*), *4921.*

S. doniana (Sm.) C. Müll. Four Sinks: On moist shaded limestone ledge, third sink in from road, *Miller 4605* (UMBS), *Vitt 892* (MICH).

Dicranum montanum Hedw. Bolton Sink: On rotting log beneath *Thuja,* S side, *Miller 4901* (with *D. viride*).

D. viride (Sull. & Lesq. ex Sull.) Lindb. Bolton Sink: On rotting log beneath *Thuja,* S side, *Miller 4901* (with *D. montanum*), *4902.*

Gymnostomum aeruginosum Sm. Bolton Sink: In crevice of dry limestone cliff face, S side of sinkhole near lip, *Miller 4907*; Four Sinks: On dry limestone ledge, sinkhole wall, third sink in from road, *Miller 4603* (UMBS).

Didymodon rigidulus Hedw. Bolton Sink: In crevice of dry limestone cliff face, S side of sinkhole near lip, *Miller 4903*; Four Sinks: On dry limy lithosol over limestone ledge, third sink in from road, *Miller 4601* (UMBS).

Bryum argenteum Hedw. Bolton Sink: On organic turf over exposed limestone boulder on floor of sink, *Miller 4593* (UMBS, with *Tortella fragilis*).

Rhodobryum roseum (Hedw.) Limpr. Bolton Sink: On rock and organic debris, shaded slope in sinkhole, *Miller 4600* (UMBS, with *Pohlia cruda).*

Mnium marginatum (With.) Brid. ex P. Beauv. Bolton Sink: On damp humus beneath *Thuja,* just above floor of sink, *Miller 4598.*

M. spinulosum B.S.G. Bolton Sink: On side of boulder near bottom of sink, *Miller 4599*; on organic debris over log, *Thuja* thicket, S side, *Miller 4911.*

Plagiopus oederiana (Sw.) Limpr. Bolton Sink: On ledge, dry cliff face, S side of sink near lip, *Miller 4917, Vitt 875* (MICH).

Orthotrichum obtusifolium Brid. Bolton Sink: On *Thuja* branch, S side, *Miller 4916* (with *O. speciosum* var. *elegans*).

O. speciosum var. *elegans* (Schwaegr. ex Hook. & Grev.) Warnst. Bolton Sink: On *Thuja* branch with *O. pallens,* S side, *Vitt 886* (MICH), *Miller 4913, 4914;* on *Thuja* branch, S side, *Miller 4916* (with *O. obtusifolium*); on *Thuja* branches, sinkhole slopes, *Vitt 880, 881* (MICH).

Thuidium recognitum (Hedw.) Lindb. Bolton Sink: On partially exposed limestone rocks, S side, *Miller 4922.*

Campylium polygamum (B.S.G.) C. Jens. Bolton Sink: On humus, floor of *Thuja* thicket, S side, *Miller 4899.*

Platydictya jungermannioides (Brid.) Crum Bolton Sink: On limestone cliff, *Vitt 878* (MICH).

Eurhynchium pulchellum var. *praecox* (Hedw.) Dix. Four Sinks: On dry, disturbed soil bank, third sink in from road, *Vitt 856* (MICH).

Plagiothecium roeseanum B.S.G. Bolton Sink: On humus, floor of shaded *Thuja* thicket, S side, *Miller 4918.*

Heterophyllium haldanianum (Grev.) Kindb. Bolton Sink: On humus, floor of *Thuja* thicket, S side, *Miller 4905.*

Diphysium foliosum (Hedw.) Mohr Four Sinks: On damp sand, shaded crest of fourth sinkhole in from road, *Miller 4604* (UMBS), *Vitt 893* (MICH).

Hepaticae

Cephalozia media Lindb. Bolton Sink: On moist decorticated log in shade of *Thuja* trees just above floor of sinkhole, *Miller 4586* (UMBS, with *Tritomaria exsectiformis* and *Dicranum flagellare*); on rotting log beneath *Thuja,* S side, *Miller 4893* (UMBS, with *Tritomaria exsectiformis*).—We have examined specimens of *Cephalozia catenulata* collected by Robinson and Wells (1956) at Bolton and Four Sinks and find them to represent *C. media.*

Geocalyx graveolens (Schrad.) Nees. Bolton Sink: On charred log beneath *Thuja* near bottom of sink, *Miller 4574* (UMBS).

Lophozia incisa (Schrad.) Dumort. Bolton Sink: On rotting, shaded, decorticated log near bottom of sinkhole, *Miller 4577* (UMBS).

Leiocolea heterocolpos (Thed.) Buch Bolton Sink: On root of living *Thuja* just above ice accumulation near bottom of sink, *Miller 4576* (UMBS); beneath *Thuja* on organic debris over rock, S side, *Miller 4887.*–Known from a number of localities across the Upper Peninsula of Michigan but apparently the only other station in this state south of the Straits of Mackinac is at the tip of the thumb near Port Austin in Huron County (Nichols, 1933).

Tritomaria exsectiformis (Breidl.) Schiffn. Bolton Sink: On moist decorticated log in shade of *Thuja* trees just above floor of sinkhole, *Miller 4586* (UMBS, with *Cephalozia media* and *Dicranum flagellare*); on shaded decorticated log near bottom of sink, *Miller 4587*; on rock above ice accumulation near bottom of sink, *Miller 4588*; on rotting log beneath *Thuja,* S side, *Miller 4893* (with *Cephalozia media*).

Plagiochila asplenioides (L.) Dumort. Bolton Sink: On humus beneath *Thuja,* S side, *Miller 4888.*

Scapania saxicola Schust. Bolton Sink: On moist side of shaded limestone boulder near bottom of sink, S side, *Miller 4890* (with *S. mucronata*), *4892.*–Known otherwise in Michigan only from the Pictured Rocks near Munising in the Upper Peninsula (Crum & Miller, 1968).

Frullania eboracensis Gottsche Bolton Sink: On bark of living *Thuja* twig, S side, *Miller 4895.*

Marchantia polymorpha L. Bolton Sink: Over *Drepanocladus uncinatus* at mouth of 'ice cave' near bottom of sink, *Miller 4591.*–Miss Ella Campbell has assigned this specimen to the var. *aquatica* Nees (see Campbell, 1969).

Conocephalum conicum (L.) Dumort. Bolton Sink: On thin organic turf, cliff face, S side near lip of sink, *Miller 4886.*

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ALGAE IN PARK LAKE, CLINTON COUNTY, MICHIGAN

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INTRODUCTION

Park Lake represents a rapidly aging, eutrophic lake in southern Michigan, where time and the disturbance of man are causing a profound and destructive influence. As in many Michigan lakes, pollution of various kinds is rapidly ruining Park Lake as a source of water and for recreation and home sites. In the spring of 1966 Dr. G. W. Prescott suggested Park Lake to me as a possible area for investigation, since a record of its present state would be desirable for reference in future studies of the changing water quality.

Park Lake is of interest because it has been neglected biologically and chemically even though it is very close to the Michigan State University campus and phycology classes have made incidental collections there for many years, especially during the spring. Knowledge of the biota and the lake chemistry are pertinent both for the history of this lake and for comparison with other lakes in southern Michigan. Furthermore, the lake is of interest because the physiography and the hydrography together with pollution factors present a unique combination of characters. The individuality of Park Lake results in part from its extreme shallowness; high percentage of floating and emergent vascular aquatic plants; and its pollution, organic and inorganic, by the residents of the area.

THE LAKE

Park Lake is located in the southeast corner of Clinton County, Michigan (T 5 N, R 1 W, Sec. 28,29), six miles to the northeast of the campus of Michigan State University. The general outline is approximately pyriform (pear-shaped) with its long axis lying in a northeast-southwest direction. It is a very shallow, productive lake of glacial origin. In 1931 it was described in the Michigan Lakes and Streams Directory (East Lansing) as follows:

> Park Lake, Clinton County; near M-78, south of Bath, near Lansing, 120 acres. A road touches lake. Extensive resort development, boat livery, good swimming, sand beach, woods on one side, flat land, lake much frequented. Large- and small-mouth bass, bluegills, perch, pike.

The situation encountered by the author is quite different from that in the above description. The community has deteriorated and the resort development is non-existent. There is little use of the lake for swimming and the dirty sand beaches are cluttered with refuse and discarded items of every variety. It was reported by Bratt (1957) that the Michigan Health Department had closed the beaches in years past because of what was referred to as chemical toilet pollution.

Along the northwest and part of the west side of the lake there is a swampy zone with marginal vegetation including a floating mat of *Decodon verticillatus* bordered shoreward by a zone of trees. The land beyond this is occupied by a muck farm. Toward the south end, the *Decodon* mat merges with a *Larix laricina* bog mat and beyond this, toward the south, there is a swampy lowland area. At the northeast end of the lake there is a public park with a boat landing. The complete shoreline of the public park is overgrown with *Typha latifolia.* Along the northern shore there is a fish bait shop and boat livery near an abandoned 'beach house' which at one time apparently offered some of the same services as the present establishment. Most of the lake supports dense growths of partly emergent vascular aquatic plants so that during the summer there is no large area of open water.

The residential community almost completely encircles the lake leaving only the margin along the *Larix* bog mat and about one-half the *Decodon* mat free from residential use.

The lake is eutrophic according to Thienemann's classificaiton system as given in Odum (1959). Bratt (1957) mentions Park Lake as a temporate lake of the third order according to the Forel and Whippel classification system, with a temporary thermocline being formed when wind and wave action are limited. Bratt did not indicate at what time of year the thermocline occurs. Observations bear out Bratt's statement that the lake is an eutrophic hard-water type with some marl precipitation.

The lake is surrounded by two major soil associations according to the map in Veatch (1953), in the legend of which the land characters and geologic-pedologic relations are indicated as follows:

(1) The Fox-Plainfield-Hillsdale-Bellefontaine Association (sandy loams, plains sands, or sand-gravel substratum):

> Undulating plains, broken by swampy depressions; in part a complex of flats of upland and swampy lowland irregular in shape and size. Relief 10 to 50 feet. Textures mostly sandy loams, but various textures included. Substrata locally gravelly, but also sands, silt and clay. Stone-free or not excessively bouldery. Acid soils; medium fertility. . . . Till plains and outwash. Gray drift weathering to reddish and yellow colors. Medium influence from limestone; variably weak to strong influence from local sandstone and shale formations. Profiles on upland mostly Gray-Brown Podzolic. Forest—on upland mostly oaks-hickory type.

(2) The Carlisle-Rifle Association (peats, mucks):

> Mostly swamp but includes some marsh. A few low mounds and ridges of upland. Mostly blackish muck on surface, but in part brown and yellow strongly acid peat. Locally very thin deposits over variable substratum clay, sands, marl. . . . Post-Glacial accumulations. Soil characteristics autogenous, but in local instances plant matter highly decomposed. Strongly developed glei horizons; locally mineral substratum strongly mottled with iron oxide; local bog iron ore pans. Forest—elm, ash, soft maples, swamp white oak; in part tamarack.

Park Lake is, in my opinion, a highly productive lake. No direct studies were conducted during my survey to evaluate the productiveness or to give experimental data to classify the lake as a productive lake. The lake is classified as a productive lake on the basis of the following inferential evidence:

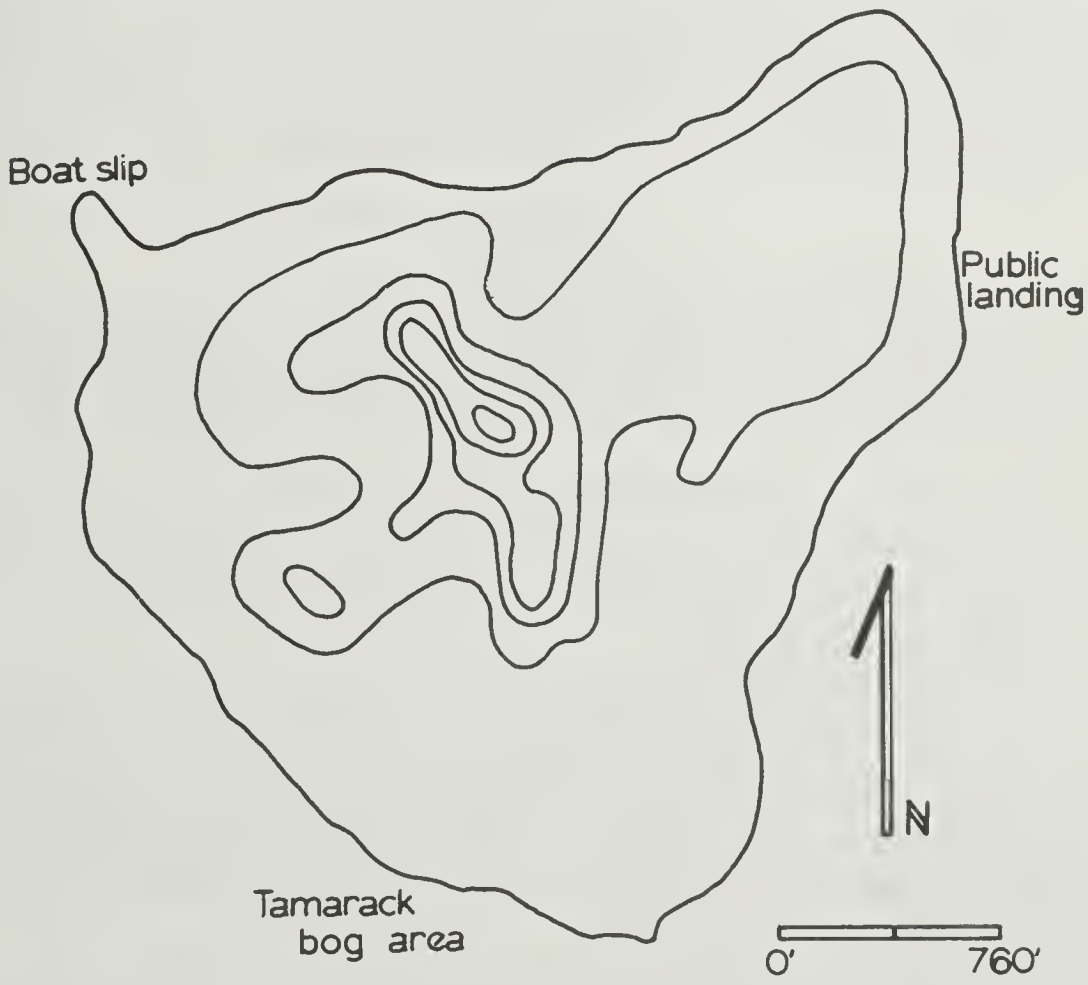
1) the observation of the lake and its abundance of vascular aquatic plants;
2) the large number of algal taxa recorded for the lake;
3) the algal blooms recorded for the lake (1938 "very abundant"; 1967, present study); (on all other occasions of water bloom reports, the lake in which the bloom occurred was reported to be productive and no unproductive lake has had a water bloom recorded for it.);
4) the high alkalinity with an abundance of bicarbonate which tends to indicate production because of increased photosynthesis.

PREVIOUS SURVEY OF THE LAKE

In 1938 the Institute for Fisheries Research, Michigan Department of Conservation, conducted a survey of the lake. This was made by a party headed by Dr. Robert C. Ball and was mostly concerned with fish and the ecological factors affecting their biology. A list of aquatic vascular plants was compiled along with some morphometric observations resulting in the hydrographic map from which the map below was redrawn (depths in 5-ft contours).

The hydrographic map of 1938 shows the area to be 185 acres with a maximum depth of 25 feet. Bratt (1957) estimated the area to be 120 acres with a maximum depth of twenty feet. Bratt also calculated the surface areas over given depths from the 1938 map as follows:

58% of surface over a depth of less than five feet
33% of surface over a depth of between five and ten feet
9% of surface over a depth of ten feet or greater.



PARK LAKE

With 91% of the lake's surface over a depth of ten feet or less, the shallowness of the lake is emphasized. Although no more recent data are available, my observations confirm the general extensiveness of shallow water.

The 1938 survey party noted that the vegetation was dense in most parts of the lake and that on two sides of the lake there were extensive encroaching bogs. It also reported most of the bottom to be covered by a pulpy peat of from four to twenty feet thick.

Bratt's 1957 master's thesis provides some limited field data which, as Bratt stated, ". . . can be used for comparison in future investigations of Park lake or other aquàtic habitats . . ." as well as a list of the invertebrates found during his investigation. Some of his data have been utilized in this work.

Since 1938 the Michigan Department of Conservation has maintained records of the lake concerned mostly with the recreational use of the lake, with specific reference to fishing. A winter fish-kill was recorded for the year 1939. An interesting letter dated September 10, 1943, from M. J. DeBoer to R. S. Kocher dealt with the possibility of using the lake for testing chemical controls on the aquatic plants and possible algicide testing. Apparently no further consideration was given to the proposal.

Since the first records on Park Lake were kept by the Institute for Fisheries Research in 1938, reports of pollution from chemical toilets have been entered periodically. Bratt (1957) was the most recent to record information concerning this pollution. During my collecting trips physical evidence of pollution was clear. The shorelines were used as a dumping ground for all types of refuse. Residential units had direct drains into the lake, as observed during the summer of 1967. Waste water from a household sink was observed flowing into the lake proper. Outdoor sanitary units were located within twenty feet of the lake edge where the shoreline was composed mainly of sand. The garbage dump for the community is located near the edge of the lake at the south end.

METHODS

For the purpose of the algal survey, permanent and incidental collecting stations were established. The three permanent stations were chosen for their biotic differences and to record the change in the flora at these stations throughout the survey. The incidental stations were mainly samples collected at random along the shoreline and as far out into the lake as the investigator could wade. When a boat was available, samples were collected from the lake area inaccessible from the shore.

The collecting period began on 13 April 1966 and was terminated on 22 November 1967, with occasional collections made up to 5 June 1968. The occasional samples were made for the purpose of augmenting the qualitative samples. The collections were made weekly during June through October; biweekly during November, December, March through May; and monthly in January and February.

During the period of study 197 samples were collected. The samples were taken from floating masses, both filamentous and non-filamentous; scrap-

ings of any non-living object in the water having a film or growth appearing on its surface; scrapings of submerged parts of aquatic vascular plants; squeezings of bottom debris and vascular aquatic plants; the first centimeter of bottom substrate; growths on animal life of the lake; masses chopped out of the ice cover; and plankton samples.

The samples were examined in the living condition and preserved in 6:3:1 solution (water–95% alcohol–formaldehyde) or FAA solution (formaldehyde–acetic acid–alcohol) (50% preservative, 50% sample) for subsequent study.

WATER BLOOM

A water bloom occurred in the lake for a period of approximately ten weeks (July 9-Sept. 16) during the summer of 1967. The major components of the bloom were *Microcystis aeruginosa, M. flos-aquae, Anabaena flos-aquae, Coelosphaerium naegelianum,* and *C. kuetzingianum.*

Jackson (1963) reported that on several occasions during his investigation of Lake Lansing, water blooms were observed. The blooms in the fall of 1959 and 1962 in Lake Lansing turned the surface waters of the shallow littoral region a pea-soup color and were composed primarily of *Microcystis aeruginosa, M. flos-aquae, Coelosphaerium naegelianum,* and *Anabaena* sp.

Jackson reported other blooms occurring with the major components being *Ceratium hirundinella* on one occasion and *Tolypothrix tenuis* on another. Park Lake had an abundance of *C. hirundinella* in the spring of 1967 but it was never in bloom proportions. *Tolypothrix tenuis* was recorded for Park Lake but it was never in abundance.

Wade (1949) conducted a study on Jordan Lake in southern Michigan that supported a water bloom during the summer months. The major components of that bloom flora were *Anabaena limnetica, A. spiroides* var. *crassa, A. circinalis* var. *macrospora, Aphanizomenon flos-aquae, Microcystis aeruginosa,* and *Coelosphaerium naegelianum.*

Edelstein (1966), in her paper on the phytoplankton of Spring Lake, Michigan, mentioned that this lake in 1957 also supported a water bloom. The major components of that bloom were *Aphanizomenon flos-aquae, Anabaena spiroides* var. *crassa, A. circinalis, Microcystis aeruginosa,* and *Aphanocapsa pulchra.*

Lakes Lansing, Jordan, Spring, and Park are all located in southern Michigan and have been recorded to support water blooms. The major constituents of the blooms have been the Cyanophyta and some of the same organisms appear in the blooms recorded for the different lakes. The Cyanophyta are the major elements of the blooms that are the producers of obnoxious conditions while the Chrysophyta and the Pyrrophyta, though noted for their bloom ability, are not the most obnoxious water bloomers. It should be noted that water blooms can occur in most highly productive lakes when the physical and chemical elements are in the proper balance and proportions. Odum (1959) states that blooms are characteristic of eutrophic lakes. Water blooms are of interest, among other aspects, because of their economic importance. Blooms cause economic loss to a recreational area by their objectional odors and by ruining the water for fishing and swimming.

SYSTEMATIC LIST OF THE ALGAE IN PARK LAKE

The names and sequence of taxa in the following systematic list are chiefly those of Prescott (1962), which also served as the basic reference for identification. New records for North America[1] are marked with +; new records for Michigan are marked with *; all are illustrated in figures 1-26.

CYANOPHYTA

Aphanocapsa elachista West & West
A. pulchra (Kütz.) Rabenhorst
Aphanothece gelatinosa (Henn.) Lemmermann
A. stagnina (Spreng.) A. Braun
Chroococcus dispersus (Keissl.) Lemmermann
C. giganteus W. West
C. limneticus Lemmermann
C. minimus (Keissl.) Lemmermann
C. minor (Kütz.) Nägeli
C. minutus (Kütz.) Nägeli
C. prescottii Drouet & Dailey in Drouet
C. turgidus (Kütz.) Nägeli
C. varius A. Braun in Rabenhorst
Coelosphaerium dubium Grunow in Rabenhorst
C. kuetzingianum Nägeli
C. naegelianum Unger
Dactylococcopsis fascicularis Lemmermann
Gloeothece rupestris (Lyngb.) Bornet in Wittrock & Nordstedt
Gomphosphaeria aponina Kützing
G. aponina var. *delicatula* Virieux
G. aponina var. *multiplex* Nygaard
G. lacustris var. *compacta* Lemmermann
Merismopedia convoluta de Brébisson in Kützing
M. glauca (Ehrenb.) Nägeli
M. punctata Meyen
M. tenuissima Lemmermann
Microcystis aeruginosa Kütz. emend. Elenkin
M. flos-aquae (Wittrock) Kirchner
M. incerta Lemmermann
Chamaesiphon incrustans Grunow in Rabenhorst
Pleurocapsa minor Hansg. emend. Geitler
Arthrospira jenneri (Kütz.) Stizenberger
**Borzia triocularis* Cohn (Fig. 3)
Lyngbya aestuarii (Mert.) Liebermann
L. birgei G. M. Smith
L. diguetii Gomont in Hariot
L. epiphytica Hieronymus in Engler & Prantl
L. hieronymi Lemmermann
L. major Meneghini
L. spirulinoides Gomont
L. taylorii Drouet & Strickland
L. versicolor (Wartmann) Gomont
Oscillatoria agardhii Gomont
O. articulata Gardner
O. bornetii Zukal
O. chalybea Mertens in Jurgens
O. curviceps C. A. Agardh
O. limnetica Lemmermann
O. limosa (Roth) C. A. Agardh
O. nigra Vaucher
O. ornata Kützing
O. princeps Vaucher
O. rubescens DeCandolle
O. subbrevis Schmidle
O. tenuis C. A. Agardh
Phormidium tenue (Menegh.) Gomont
Schizothrix tinctoria Gomont
Spirulina princeps (West & West) G. S. West
S. subsalsa Oersted
Trichodesmium lacustre Klebahn
Anabaena flos-aquae (Lyngb.) deBrébisson
A. oscillarioides Bory
Nostoc comminutum Kützing
Microchaete goeppertiana Kirchner in Engler & Prantl
+*Scytonema bohneri* Schmidle (Figs. 1,2)
Tolypothrix lanata Wartmann in Rabenhorst
T. tenuis Kütz. emend. J. Schmidt
Calothrix atricha Frémy
C. breviarticulata West & West
C. epiphytica West & West
C. stellaris Bornet & Flahault
Gloeotrichia echinulata (J. E. Smith) P. Richter
G. pisum (C. A. Ag.) Thuret

CHLOROPHYTA

Chlamydomonas globosa Snow
C. polypyrenoideum Prescott
C. pseudopertyi Pascher
Eudorina elegans Ehrenberg
Gonium pectorale Müller
Pandorina morum (Müll.) Bory
Ploeodorina californica Shaw

[1]*Scenedesmus armatus* var. *boglariensis* f. *semicostatus* and *S. tibiscensis* were previously recorded for North America in an unpublished thesis by Ronald W. Hoham (1966).

Volvox aureus Ehrenberg
V. tertius A. Meyer
Asterococcus superbus (Cienk.) Scherffel
Gloeocystis ampla (Kütz.) Lagerheim
G. gigas (Kütz.) Lagerheim
G. planctonica (West & West) Lemmermann
Palmella mucosa Kützing
Sphaerocystis schroeteri Chodat
Apiocystis brauniana Nägeli
Tetraspora gelatinosa (Vauch.) Desvaux
Dispora crucigenioides Printz
Elakatothrix viridis (Snow) Printz
Binuclearia tatrana Wittrock
Geminella interrupta (Turp.) Lagerheim
G. minor (Näg.) Heering
Hormidium klebsii G. M. Smith
Radiofilum flavescens G. S. West
Ulothrix tenerrima Kützing
Uronema elongatum Hodgetts
Microspora elegans Hansgirg
M. loefgrenii (Nordst.) Lagerheim
M. pachyderma (Wille) Lagerheim
M. stagnorum (Kütz.) Lagerheim
Cylindrocapsa conferta W. West
Aphanochaete polychaete (Hansg.) Fritsch
A. repans A. Braun
Chaetophora attenuata Hazen
C. incrassata (Huds.) Hazen
Pseudulvella americana (Snow) Wille
Stigeoclonium lubricum (Dillw.) Kützing
S. subsecundum Kützing
S. tenue (C. A. Ag.) Kützing
Protococcus viridis C. A. Agardh
Chaetosphaeridium ovalis G. M. Smith
Coleochaete irregularis Pringsheim
C. scutata de Brébisson
Gongrosira debaryana Rabenhorst
Basicladia chelonum (Collins) Hoffman & Tilden
B. crassa Hoffman & Tilden
Cladophora crispata (Roth) Kützing
C. insignis (C. A. Ag.) Kützing
Rhizoclonium crassipellitum West & West
R. hieroglyphicum (C. A. Ag.) Kützing
**Oedogonium capitellatum* Wittrock (Fig. 5)
O. howardii G. S. West
O. poecilosporum Nordstedt & Hirn in Hirn
O. pratense Transeau
O. spirostriatum Tiffany
Botryococcus braunii Kützing
B. sudeticus Lemmermann
Characium ambiguum Hermann
C. dabaryanum (Reinsch) DeToni
C. falcatum Schroeder
Pediastrum araneosum (Racib.) G. M. Smith
P. boryanum (Turp.) Meneghini
P. boryanum var. *longicorne* Raciborski
P. duplex var. *clathratum* (A. Braun) Lagerheim
P. duplex var. *rugulosum* Raciborski
P. integrum Nägeli
P. obtusum Lucke
P. tetras (Ehrenb.) Ralfs
P. tetras var. *tetraodon* (Corda) Rabenhorst
Sorastrum spinulosum Nägeli
Coelastrum microporum Nägeli in A. Braun
Ankistrodesmus falcatus (Corda) Ralfs
A. falcatus var. *tumidus* (West & West) G. S. West
Chlorella vulgaris Beyerinck
Closteriopsis longissima var. *tropica* West & West
Gloeotaenium loitelsbergerianum Hansgirg
Nephrocytium agardhianum Nägeli
N. limneticum (G. M. Smith) G. M. Smith
Oocystis borgei Snow
O. elliptica W. West
O. gigas Archer
O. parva West & West
O. solitaria Wittrock in Wittrock & Nordstedt
Planktosphaeria gelatinosa G. M. Smith
Quadrigula lacustris (Chod.) G. M. Smith
Rayssiella hemisphaerica Edelstein & Prescott
Tetraedron minimum (A. Braun) Hansgirg
T. muticum (A. Braun) Hansgirg
Trochiscia reticularis (Reinsch) Hansgirg
Zoochlorella parasitica Brandt
Crucigenia rectangularis (A. Braun) Gay
**Pectodictyon cubicum* Taft (Fig. 26)
Scenedesmus acutus Meyen
+*S. acutus* f. *alternans* Hortob. (Fig. 8)
+*S. acutus* f. *tetradesmiformis* (Wolosz.) Uherkovich (Fig. 9)
S. arcuatus Lemmermann
S. arcuatus var. *platydiscus* G. M. Smith
**S. armatus* var. *boglariensis* f. *semicostatus* Hortob. (Fig. 11)
+*S. bicaudatus* (Hansg.) Chodat (Fig. 6)
S. brevispinus (G. M. Smith) Chodat
S. ecornis (Ralfs) Chodat
S. ecornis var. *discidormis* Chodat
S. longus var. *naegelii* de Bréb.) G. M. Smith
S. ovalternus Chodat
S. quadricauda (Turp.) de Brébisson in de Brébisson & Gody
S. quadricauda var. *longispinus* (Chod.) G.M. Smith
S. quadricauda var. *maximus* West & West
S. quadricauda var. *quadrispinus* (Chod.) G. M. Smith
S. spinosus Chodat
**S. tibiscensis* Uherkovich (Fig. 7)
Tetradesmus wisconsinensis G. M. Smith
Sirogonium sticticum (Engler) Kützing

Explanation of Figures 1-25 (taxa previously unreported from Michigan).

1. & 2. *Scytonema bohneri*; plant occurring in small tufts on substrate; trichome branches frequently exhibiting both *Scytonema*-type branches and *Tolypothrix*-type branches; sheath thin and not lamellated, cells appearing quadrate; veg. cell diam. 8-10μ.

3. *Borzia trilocularis*; trichome of three to five barrel-shaped cells, terminal cells hemispherical; trichome diam. 14μ, L. 9μ.

4. *Cosmarium garrolense* var. *dimido-minus*; variety distinguished from typical by its smaller size; diam. 14μ, L. 23μ, Ism. 3μ.

5. *Oedogonium capitellatum*; oospore spore wall smooth, operculum median, macrandrous and monoecious; veg. cell diam. 7μ, L. 31μ; oogonia diam. 24μ, L. 22μ; oospore diam. 15μ, L. 20μ.

6. *Scenedesmus bicaudatus*; oval cells tightly appressed with the terminal cells of the coenobium each bearing one spine on opposite poles; diam. 5-6μ, L. 13-15μ, spine L. 10μ.

7. *Scenedesmus tibiscensis*; coenobium of alternating angular cells; diam. 3μ, L. 12-14μ.

8. *Scenedesmus acutus* f. *alternans*; alternating coenobium, inner cells angular-clavate, terminal cells lunate with swelling on inner curve; diam. 5μ, L. 17.5μ.

9. *Scenedesmus acutus* f. *tetradesmiformis*; coenobium composed of fusiform cells; diam. 7μ, L. 25μ.

10. *Cosmarium conspersum* f. *minus*; variety distinguished from typical by smaller size; diam. 42μ, L. 54μ, Ism. 18μ.

11. *Scenedesmus armatus* var. *boglariensis* f. *semicostatus*; terminal cells of coenobium bearing a long spine at each pole; median cells having a prominent longitudinal median rib; diam. 4-4.5μ, L. 16μ.

12. *Cosmarium minutissimum*; diminutive size characteristic; diam. 13μ, L. 15μ, Ism. 2μ.

13. *Cosmarium humile* var. *danicum*; apical granules and smaller size distinguish it from typical; diam. 15μ, L. 17μ, Ism. 6μ.

14. *Cosmarium humile* var. *glabrum*; lack of apical granules characteristic, diam. 13.5μ, L. 15μ, Ism. 4μ.

15. *Cosmarium regnellii*; concave apex, open notch at side of apex and lateral depression characteristic; diam. 14μ, L. 17μ, Ism. 3μ.

16. *Euastrum turneri* var. *strictum*; deep apical notch and the smoothly undulating margin with projecting spines and granules are characteristic; diam. 27μ, L. 41μ, Ism. 6μ.

17. *Staurastrum disputatum* f. *minus*; size characteristic; diam. 13μ, L. 20μ, Ism. 9μ.

18. *Cosmarium depressum*; subspecific taxa previously reported for Michigan, first record of typical; wall is punctate, oval in apical view; diam. 52μ, L. 54μ, Ism. 14μ.

19. *Staurastrum cosmarioides;* large size, punctate wall, and triradiate arrangement are characteristic; diam. 60μ, L. 95μ, Ism. 30μ.

20. *Euglena fusca*; subcylindrical form, size, and pellicle (smooth in this specimen) are characteristic; diam. 20μ, L. 155μ.

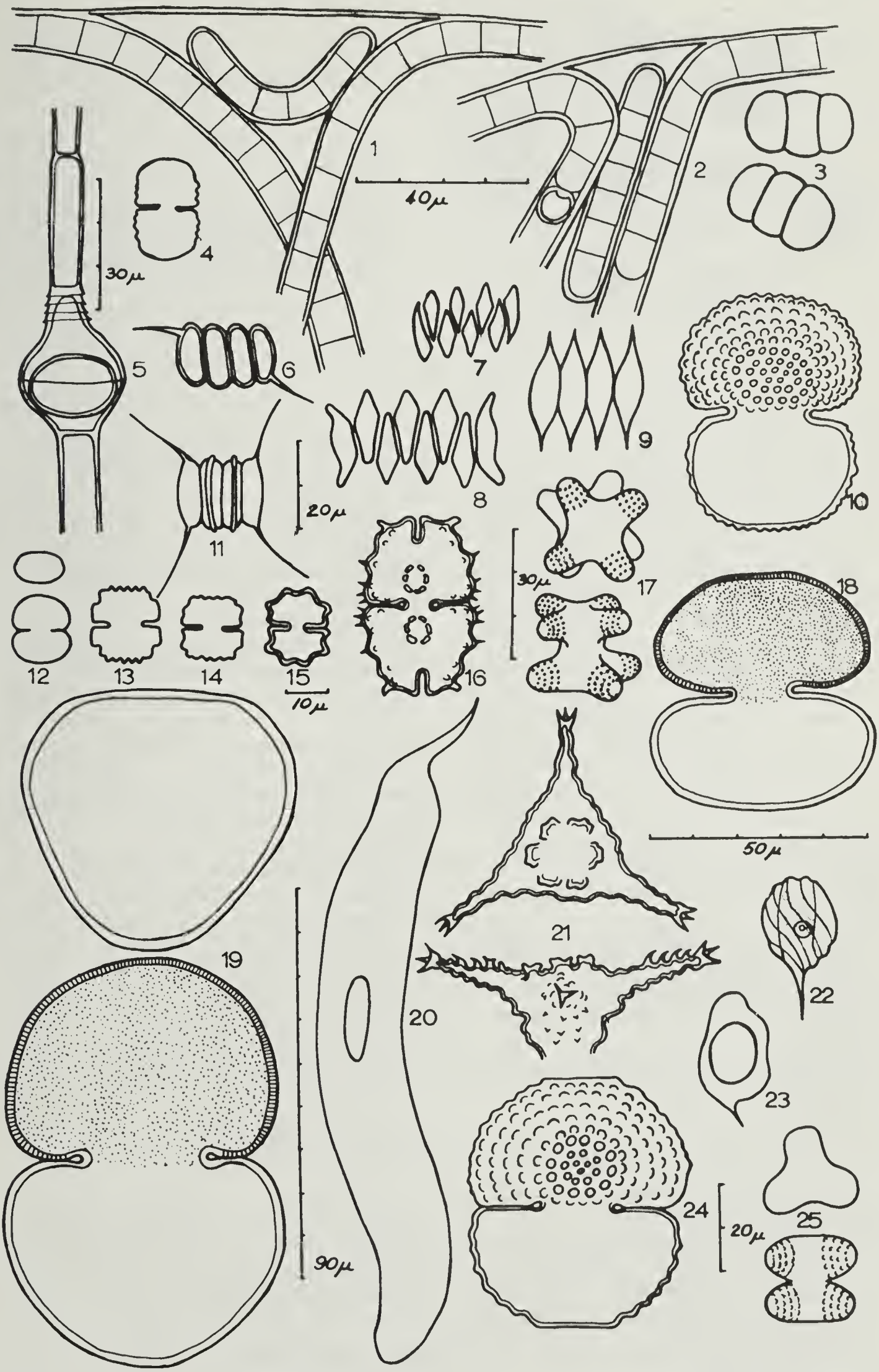
21. *Staurastrum cyclacanthum* var. *subacanthum;* considered to be the var. *subacanthum* on the basis of size and thickness of the central portion of the cell when viewed apically; diam. 45μ L. 40μ, Ism. 10μ.

22. *Phacus pseudonordstedtii*; the two large paramylon bodies at the lateral margins, the straight caudus, and the left to right spiral striations in the pellicle are characteristic; diam. 15μ, L. 33μ.

23. *Phacus obolus*; size, the large central paramylon body, and the straight to slightly bent caudus are characteristic; diam. 15μ, L. 30μ.

24. *Cosmarium sportella*; granular cell wall with central roset of granules are characteristic; oval in apical view; diam. 50μ, L. 58μ, Ism. 17μ.

25. *Staurastrum punctulatum* var. *minus*; size characteristic; diam. 18μ, L. 20μ, Ism. 8μ.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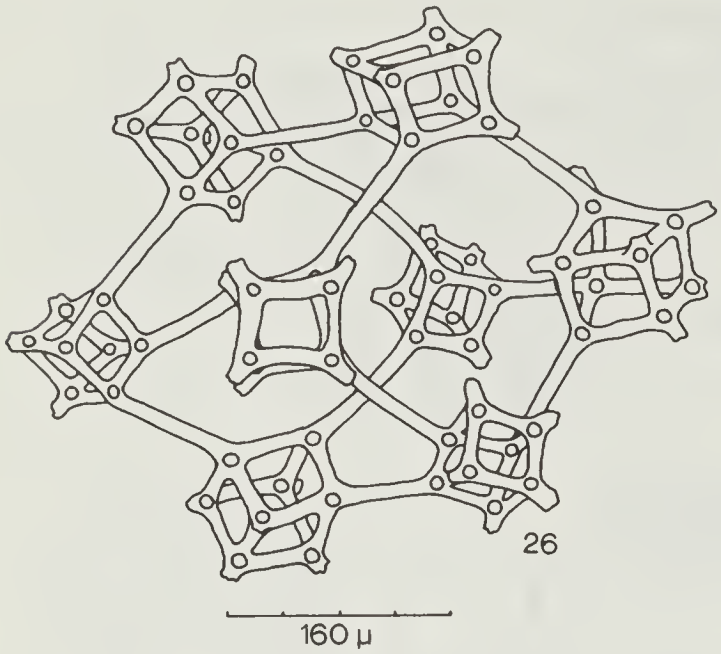

Fig. 26. *Pectodictyon cubicum* (after Taft, 1945); the unusual coenobium is very characteristic; veg. cell diam. 7μ.

Spirogyra crassa Kützing
S. longata (Vauch.) Kützing
Zygnema sterile Transeau in Transeau, Tiffany, Taft, & Li
Closterium dianae Ehrenberg
C. ehrenbergii Meneghini
C. jenneri Ralfs
C. leiblenii Kützing
C. libellula Focke
C. monoliferum (Bory) Ehrenberg
C. parvulum Nägeli
C. venus var. *westii* (West) Krieger
Cosmarium angulare Johnson
C. angulosum de Brébisson
C. botrytis Meneghini
**C. conspersum* f. *minus* Borge (Fig. 10)
C. denticulatum var. *borgei* Irénée-Marie
**C. depressum* (Näg.) Lundell (Fig. 18)
C. depressum var. *schroederi* Krieger & Gerloff
+C. garrolense var. *dimido-minus* (Gröblad) Krieger & Gerloff (Fig. 4)
C. humile (Gay) Nordstedt in DeToni
**C. humile* var. *danicum* (Borge) Schmidle (Fig. 13)
**C. humile* var. *glabrum* Gutwinski (Fig. 14)
**C. minutissimum* Archer (Fig. 12)
C. obtusatum Schmidle
C. portianum Archer
C. pseudopyramidatum Lundell
**C. regnelli* Wille (Fig. 15)
C. reniforme (Ralfs) Archer
C. sexangulare f. *minimum* Nordstedt
**C. sportella* de Brébisson (Fig. 24)
C. subcostatum Nordstedt
C. subtumidum Nordstedt
C. trilobulatum Reinsch
C. tumidum Lund
C. turpinii de Brébisson
C. undulatum var. *minutum* Wittrock
Desmidium aptogonum de Brébisson
D. baileyi (Ralfs) Nordstedt
Euastrum hypochondrum f. *decoratum* Scott & Prescott
**E. turneri* var. *strictum* (Börges.) Scott & Prescott (Fig. 16)
E. verrucosum Ehrenberg
Hyalotheca dissiliens (Smith) de Brébisson
H. mucosa (Dillw.) Ehrenberg
Micrasterias truncata var. *semiradiata* (Näg.) Cleve
Penium margaritaceum (Ehrenb.) de Brébisson in Ralfs
Pleurotaenium ehrenbergii (de Bréb.) DeBary
P. trabecula (Ehrenb.) Nägeli
Staurastrum cornutum Archer
**S. cosmarioides* Nordstedt (Fig. 19)
S. crenulatum (Näg.) Delpont
+S. cyclacanthum var. *subacanthum* Grönblad (Fig. 21)
+S. disputatum f. *minus* West & West (Fig. 17)
S. furcigerum de Brébisson
S. gracile Ralfs var. *nanum* Wille
S. hexacerum (Ehrenb.) Wittrock
S. johnsonii West & West
S. longiradiatum West & West
S. manfeldtii Delpont
+S. punctulatum var. *minus* West & West (Fig. 25)
S. sebaldi Reinsch var. *ornatum* Nordstedt
S. vestitum Ralfs
Xanthidium antilopaeum (de Bréb.) Kützing
Chara globularis Thill.
C. vulgaris Linnaeus

EUGLENOPHYTA

Euglena elastica Prescott

**E. fusca* (Klebs) Lemmermann (Fig. 20)
E. gracilis Klebs
E. proxima Dangeard
Lepocinclis acuta Prescott in Prescott, Silva, & Wade
Phacus caudatus Hübner
P. contortus var. *complicatus* Bourrelly
P. curvicauda Swirenko
P. longicauda (Ehrenb.) Dujardin
P. longicauda var. *insectus* Kozw.
+P. obolus Pochmann (Fig. 23)
P. orbicularis Hübner
+P. pseudonordstedtii Pochmann (Fig. 22)
P. pseudoswirenkoi Prescott
P. suecicus Lemmermann in Pascher & Lemmermann
P. undulatus (Skv.) Pochmann
Trachelomonas hispida (Perty) Stein
T. volvocina Ehrenberg

PYRROPHYTA

Glenodinium pulvisculus (Ehrenb.) Stein
Peridinium gatunense Nygaard in Ostenfeld & Nygaard
P. inconspicuum Lemmermann
P. pusillum (Penard)Lemmermann
P. umbonatum Stein
P. volzii Lemmermann
P. willei Huitfeld-Kaas
Ceratium hirundinella (O. F. Müll.) Dujardin
Cystodinium cornifax (Schill.) Klebs

CHRYSOPHYTA

Ophiocytium cochleare (Eichw.) A. Braun
O. parvulum (Perty) A. Braun
Synura uvella Ehrenberg
Dinobryon cylindricum Imhof ex Ahlstrom
D. sertularia Ehrenberg
D. tabellariae (Lemm.) Pascher in Pascher & Lemmermann
Uroglenopsis americana (Calkins) Lemmermann
Cyclotella sp.
Melosira sp.
Tabellaria sp.
Asterionella sp.
Fragilaria spp.
Synedra spp.
Synedra delicatissima W. Smith (Det. Begres)
Eunotia sp.
Cocconeis sp.
Amphipleura sp.
Gyrosigma sp.
Navicula spp.
Neidium sp.
Pinnularia spp.
Stauroneis sp.
Gomphonema spp.
Amphora spp.
Cymbella spp.
Epithemia sp.
Rhopalodia sp.
Nitzschia spp.
Cymatopleura sp.
Surirella sp.

Because of the problems involved in diatom taxonomy, the Bacillariophyceae were mostly not identified to species, although those genera are indicated which were represented by more than one species. In addition, specimens referable to the following genera were collected but were either immature or lacked the necessary features for specific identification and hence it could not be determined whether they represented taxa otherwise unknown from the lake: *Stigeoclonium, Gongrosira, Pithophora, Bulbochaete, Oedogonium, Mougeotia, Spirogyra, Zygnema, Euglena, Lepocinclis, Phacus,* and *Vaucheria.*

SUMMARY AND CONCLUSIONS

Park Lake is a shallow, eutrophic lake of glacial origin, located in the southeast corner of Clinton County, six miles from the campus of Michigan State University. In recent years, the eutrophication process has been enhanced by increased pollution. It is a rapidly aging lake with a high density of vascular aquatic plants and an abundant algal flora.

The algae can be assigned to the following divisions from the collections made:

DIVISION	GENERA	TOTAL TAXA	% OF TOTAL
Cyanophyta	26	74	22.1
Chlorophyta	71	200	59.7
Euglenophyta	4	21	6.3
Pyrrophyta	4	9	2.7
Chrysophyta	27	31	9.2

Of the 335 taxa recorded from the 197 samples collected, 25 are newly recorded for Michigan, of which 10 are new for North America.

The flora is co-dominated in number of species by the Chlorophyta and the Cyanophyta. The Euglenophyta, Pyrrophyta, and Chrysophyta comprise only 18.2% of the total algal flora of the lake. The importance of the Chrysophyta must not be disregarded or minimized by the above percentage as they were not all identified to species, the Bacillariophyceae (diatoms) being identified to the generic level only.

The littoral community includes more than twice the number of taxa as the limnetic community.

The lake supported a continuous water bloom for a period of approximately ten weeks during the summer of 1967. The bloom flora of Park Lake was similar to that of Lake Lansing, but differed from the bloom flora in Jordan Lake and Spring Lake in respect to their dominants.

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Publications of Interest

A PHOTO GUIDE TO THE PATTERNS OF DISCOLORATION AND DECAY IN LIVING NORTHERN HARDWOOD TREES. By Alex L. Shigo & Edwin vH. Larsen. Northeastern Forest Experiment Station, Upper Darby, Pennsylvania (U.S.D.A. Forest Service Research Paper NE-127), 1969. 100 pp. One hundred color photos illustrate how discoloration and decay form in northern hardwood trees and show how interior defects can be estimated from external indications on the living tree. Damage from fungi and animals are both included.

DEFICIENCY SYMPTOMS OF SOME FOREST TREES. By John Hacskaylo, R. F. Finn, & J. P. Vimmerstedt. Ohio Agricultural Research and Development Center, Wooster, Ohio (Research Bulletin 1015), 1969. 68 pp. Another bulletin copiously illustrated with color photos showing results of various nutrient deficiencies on the color and development of leaves and roots of black walnut, black locust, cottonwood, sweetgum, and Scots pine.

MORPHOLOGY OF THE FUNGAL ASSOCIATION IN THREE SPECIES OF *CORALLORHIZA* IN MICHIGAN

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In the summer of 1968 I investigated the fungal associations of three species of *Corallorhiza* which grow in northern Michigan, namely *C. trifida* Chatelain, *C. maculata* Raf., and *C. striata* Lindl.

Material of the orchid rhizomes and adjacent tree roots was collected in July and August. After the material had been washed in water, promising pieces were killed and fixed in formalin-acetic-alcohol, infiltrated with paraffin, and sectioned by microtome. In many cases fine tree-roots were lying close to the orchid rhizomes and held attached in this position by fungal hyphae or by rhizomorphs. In serial sections cut at 10μ it was possible to follow hyphae from the roots into the orchid rhizomes. Staining of the sections with safranin and fast green gave satisfactory contrast.

Corollorhiza trifida

C. trifida is found in Europe and Asia as well as in North America. Its mycorrhiza has been studied previously. Jennings and Hanna (1898) using the name *C. innata* R.Br. for their specimens, which came from the eastern European Alps, mention that the plants are not entirely colorless, for, although the reduced leaves lack chlorophyll, the flowers and the upper part of the scape may be pale yellow-green. They draw attention to the tufts of mykokleptic hairs, which Thomas (1893) had earlier observed projecting from papillae on the rhizome, and describe the passage of septate hyphae through the hairs and the outer layers of the rhizome to a zone of cells occupied by fungal coils and eventually to a deeper zone where collapse of the coils occurs. In one instance they found sporophores of *Clitocybe infundibuliformis* Sch. growing from mycelium around the rhizome, but on other occasions the sporophores found in close proximity to the orchid belonged to other Basidiomycetes.

In northern Michigan the plants of *C. trifida* show slight green coloration in the flowering stem, the basal leaf, and the ovary. On the surface of the coralloid rhizomes are numerous papillae-bearing hairs (Fig. 1). Also present on the rhizomes are fungal hyphae which can be followed either as single threads or as rhizomorphs to the fine roots of *Thuja occidentalis* L. or of *Picea* spp. In some cases the fungal threads are yellowish in color, in other cases white.

The yellowish fungus corresponds with *Mycena thujina* Smith. In living *Thuja* roots it is present in the cortical cells and in dead roots it is in the vascular cylinder as well. It enters the orchid by way of the hairs (Fig. 1), spreads in a cylinder around the rhizome at a depth of 3 to 6 cells from the surface, and then enters deeper cells where the fungal coils, which form at

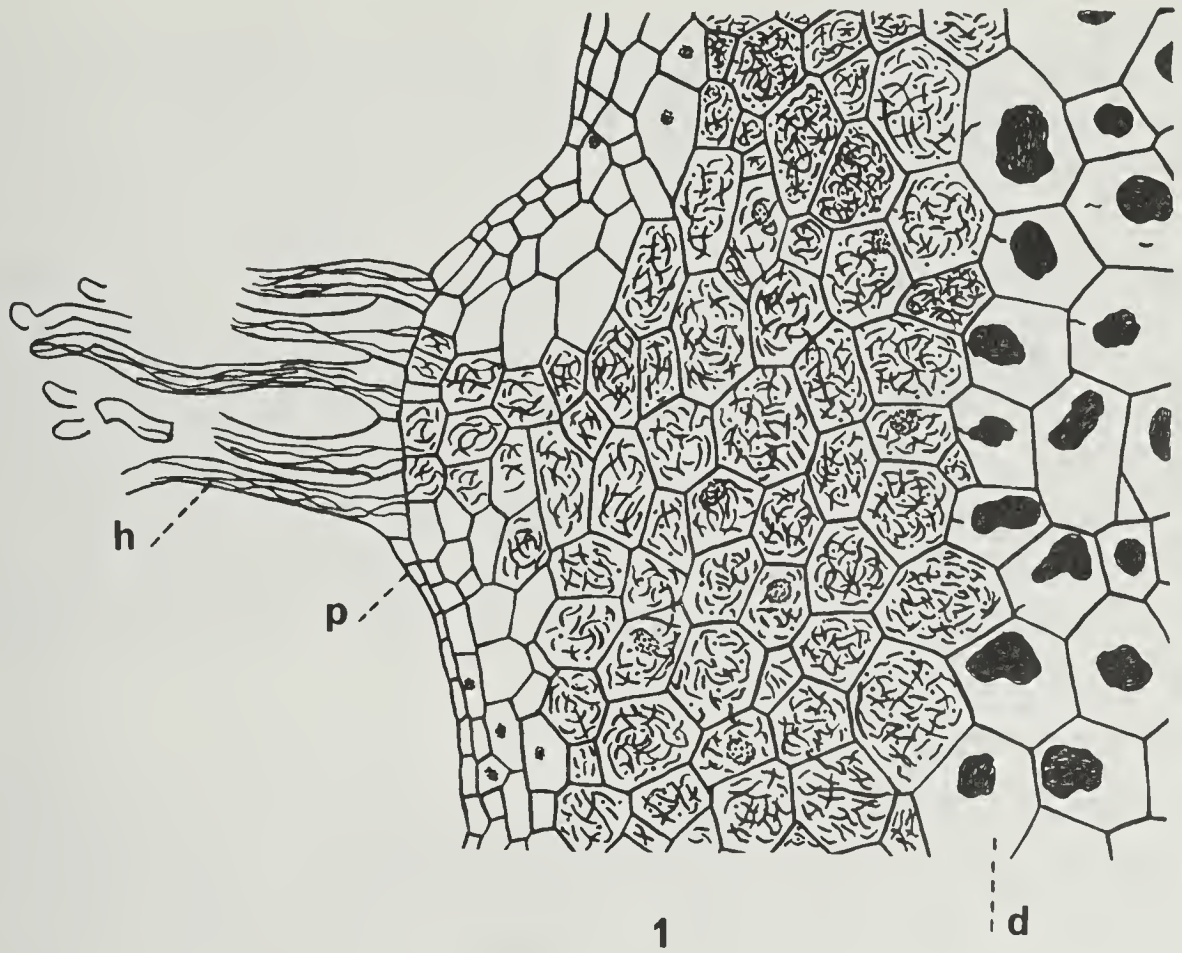

Fig. 1. Part of the rhizome of *C. trifida* in transverse section. x 185. d. zone of fungal digestion; h. hair; p. papilla.

Fig. 2. Part of the rhizome of *C. maculata* in transverse section. x 185.

first, eventually collapse. The hyphae are septate with clamp connections and are of diameter 3μ. In the rhizomorphs the central hyphae lie parallel longitudinally, while interwoven peripheral hyphae lie horizontally in a cylinder.

The white fungus occurs either as single hyphae or as rhizomorphs, up to 0.16 mm in diameter, in which the hyphae lie somewhat interwoven in a lengthwise direction. Most of the hyphae of the rhizomorph are of diameter 3 to 6μ and show clamp connections, but 6 to 8 central hyphae are much wider, with a diameter up to 47μ. The outermost hyphae tend to have thickened walls and to lack clamp connections. Sometimes the rhizomorphs lie in the axils of the scale leaves on the orchid rhizomes. They can be followed to adjacent roots, where, as hyphae, they enter the cells of the cortex and in dead roots the vascular cylinder also. Hyphae departing from the rhizomorphs infect the orchid plants through hairs on the papillae and appear within the rhizomes as does the yellowish fungus.

Corallorhiza maculata

C. maculata has no chlorophyll in any part of the plant. It is endemic to North America. The 20 plants selected for investigation were from flourishing colonies, as indicated by the number of new flowering spikes present and of old fruiting spikes of the previous year. They were collected from a variety of situations, as from beech-oak forest under trees of *Fagus grandifolia* Ehrh. and *Quercus rubra* L., from beech-maple forest under *Fagus grandifolia* and *Acer saccharum* Marsh., from oak-maple forest under *Quercus rubra* and *Acer saccharum*, and elsewhere under pure stands of *Betula papyrifera* Marsh., of *Thuja occidentalis*, of *Pinus strobus* L., of *Pinus resinosa* Ait., and of *Populus grandidentata* Michx.

The underground portion of the orchid consists of pale, coralloid, fleshy rhizomes, up to 4 mm in diameter, lying horizontally in the litter layer amongst decaying twigs, fallen leaves, and the roots of trees. The orchid itself has no roots. On the surface of the rhizome, besides ring-like depressions at the nodes and the tattered remnants of vestigial scale leaves, there are numerous conical or hemispherical papillae bearing projecting hairs or appearing as brown lesions after the hairs have withered off. Against the rhizomes lie the fine rootlets of trees, many of which are already rotted internally, leaving only an outer shell to maintain the form of the rootlet. Associated with 17 of the specimens that were examined, rhizomorphs of *Armillaria mellea* (Vahl. ex Fr.) Kummer were found nearby in the litter. These rhizomorphs, as well as penetrating the roots of adjacent trees, also break up into white strands and into hyphae which lie along the orchid rhizomes and are anchored at intervals to the hairs. In two specimens, the fungus was a different one with yellow strands, and in a further specimen the strands had a few wide, centrally placed hyphae surrounded by narrower ones. In all the fungi involved, the hyphae were septate without clamp connections.

The structure of the orchid rhizome was studied microscopically in transverse and longitudinal sections. There is a central vascular cylinder with 4 to 6 vascular bundles enclosed by an endodermis with Casparian bands. The

cortex, 16 to 20 cells in width, consists of starch-storing parenchyma. At the surface is an epidermis with a cuticle. The papillae scattered over the rhizome, and sometimes also on the bases of the scale leaves, are 6 to 10 cells wide at the base and 5 to 6 cells high; they carry rather stiff unicellular hairs up to 0.5 mm in length (Fig. 2).

The fungal infection of the rhizome follows a characteristic course. Fungal strands and individual hyphae often lie appressed to the epidermis in the depressions at the nodes, but penetration occurs only through the tips of hairs on those papillae lying a short distance back from the growing-point. The entering hyphae grow down the hair and at first spread through the cells of the papilla in a loose branching meshwork. The nucleus of infected cells enlarges and becomes lobed as some of the hyphae lose their content and collapse, but other hyphae remain intact. The basal wall of the hair cell and sometimes the innermost wall of deeper cells of the papilla becomes thickened and brown but gives no reaction for lignin or suberin. Later, when the hairs have withered, the thickened walls persist as a scar over the papilla. Hyphae from the papilla region enter the cortex and spread laterally and inwards in a definite pattern (Fig. 2). The epidermis and outer 2 to 3 rows of the cortex remain free of fungus. There is next a belt, 2 rows of cells in width, which harbours the fungus without apparently being affected by it. But in deeper cells the position is different. In a belt some 5 to 9 rows in depth the fungus first occupies the cells with branching coiling hyphae. The nucleus of infected cells enlarges and tends to become lobed while the hyphae, which at first contain much protoplasm, lose their content and collapse, leaving only a densely staining clump of unabsorbed material at the centre of the cell. A belt, 3 to 6 rows wide, outside the endodermis is not penetrated by the fungus and the cells here retain their starchy contents and accumulate fatty oils as well.

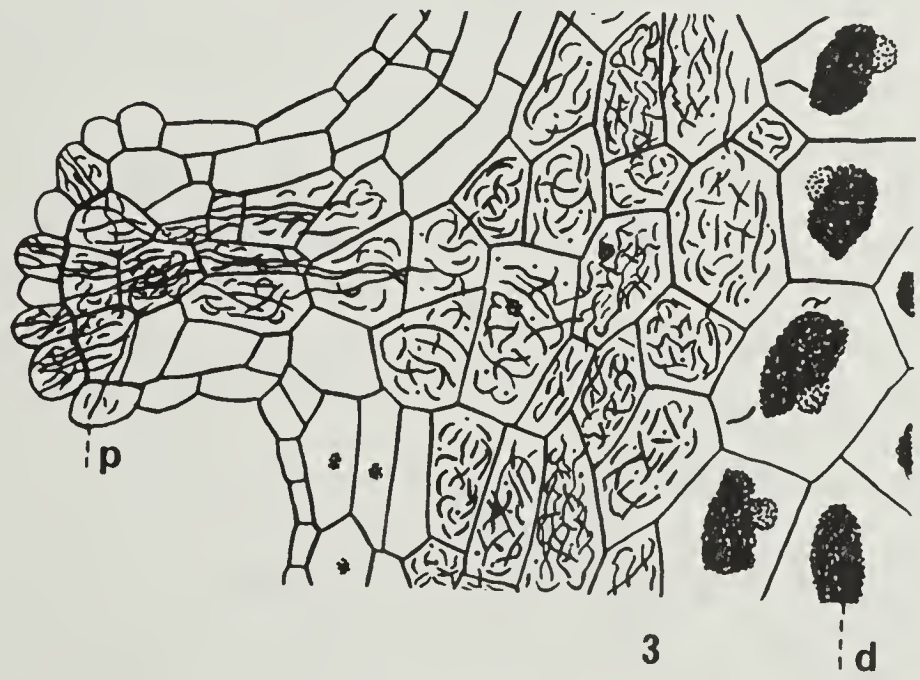

Fig. 3. Part of the rhizome of *C. striata* in transverse section. x 185. d. zone of fungal digestion. p. papilla.

Corallorhiza striata

C. striata is another non-green orchid which is endemic to North America. In northern Michigan it grows amongst the roots of a variety of trees. The 10 specimens selected for investigation were collected from under *Thuja occidentalis* and *Picea* sp., from under *Thuja occidentalis* and *Betula lutea* Michx. f., from under *Quercus rubra* and *Acer saccharum*, and from pure stands of *Pinus strobus*, of *Pinus resinosa*, of *Fagus grandifolia*, and of *Betula papyrifera.*

The underground portion of the orchid consists of a branching system of rhizomes, each 2 - 5 mm in diameter and lying more or less horizontally in the litter layer amongst fallen leaves and the fine roots of forest trees. Sometimes the rhizomes resemble in appearance those of *C. maculata*; at other times they are brown in colour with short, white, fungal-free tips. They have no roots.

Transverse sections of the rhizome show an internal structure resembling that of *C. maculata.* The central vascular cylinder has 3 to 12 small vascular bundles enclosed by an endodermis with Casparian bands. There is a parenchymatous cortex, 16 to 17 cells in width, and at the surface there is an epidermis with a cuticle. The papillae are 4 to 14 cells in diameter and 3 to 8 cells high. However, their surface cells, unlike those of the two previous species, have convex outer walls but no projecting hairs (Fig. 3).

Two different fungi were found associated with the rhizomes. In one of these the hyphae, which are of a diameter of 3 - 4.5μ, have a brown, external wall except near the growing tips and are septate without clamp connections. The brown walls give the brown colour to the rhizomes in which they become established. This fungus in one area is also mycorrhizal on the roots of the *Pinus strobus* alongside the orchid and grows as a fungal mantle and Hartig net on the pine roots. In another area the fungus is mycorrhizal as a fungal mantle and Hartig net on the roots of either *Acer saccharum* or *Quercus rubra*. In *Thuja* roots there is no superficial mantle but the fungus is in the cortex, penetrating first along the walls and later lying in the cell cavities, and penetrating into the vascular cylinder of dead roots. In the case of the other fungus the hyphae within the orchid rhizome are colourless and of diameter 1.5 - 3μ, but outside the rhizome they may have brown walls; they are septate without clamp connections. They are also to be found in the cortical cells of the fine roots of *Betula papyrifera* and in the cortex and vascular cylinder of fine roots of the *Fagus grandifolia.* Most of the fine roots of *Fagus* near the orchid were found to be dead.

The fungus enters the orchid rhizome through surface cells of papillae near the growing tips. These surface cells appear to be a special point of entry for the fungus. Their basal walls later become thickened and suberized. The hyphae grow through the papilla into the cortex where they spread laterally (Fig. 3). The epidermis and outer 2 to 4 rows of cortical cells remain free of fungus. There is then a belt, 3 to 5 cells wide, occupied by fungal coils, or, in the case of the colourless fungus, by a fungal meshwork, followed by a zone 4 to 7 cells wide in which the coils eventually collapse leaving only a darkly

staining clump of unabsorbed material. The innermost cortical cells remain free of fungus and contain starch.

DISCUSSION

All three species of *Corallorhiza* were found to be able to form an association with more than one species of fungus. This supports the findings of earlier workers for *C. innata* (Jennings & Hanna, 1898). The condition, however, contrasts with that in such examples as *Gastrodia cunninghamii* where the orchid is associated with one particular fungus (Campbell, 1962).

The surface cells of the papillae in *C. striata* and the tips of the hairs projecting from the papillae of both *C. striata* and *C. maculata* are the point of entry to the rhizome for certain fungi. However, for each species of *Corallorhiza* there is a particular range of fungi, as indicated by the fact that only in *C. trifida* do the fungi show clamp connections and only in *C. striata* is the brown-walled fungus found. Once the fungus has entered the rhizome, its advance into the cortex and later its digestion by tolypophagy follows a similar pattern in all three species.

Some of the fungi concerned are inhabitors of the roots of trees where they behave as weak parasites. But they also flourish in the soil amongst the trash of wood and bark left after felling operations or left after snow and wind damage. Others are mycorrhizal on roots of adjacent trees.

The orchid, particularly in the case of *C. trifida,* although obviously obtaining nourishment from the fungus, forms a relatively harmonious association with it, for the infected cells suffer no obvious damage. This situation contrasts with that in some other orchids, such as *Gastrodia minor,* where the infected region of the tuber ultimately collapses (Campbell, 1963).

ACKNOWLEDGMENTS

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SPHAGNUM IN CHARLEVOIX COUNTY, MICHIGAN

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As a result of its history of glaciation, Michigan abounds in poorly drained habitats favorable to the growth of *Sphagnum.* In recent years considerable interest in the taxonomy, distribution, and ecology of the genus, so poorly understood by American bryologists, has centered around the University of Michigan Biological Station in northern Michigan. Access to the abundance of collections made by numerous bryologists visiting the area or by students in bryology over a period of 50 years has enabled the junior author to confirm records of 25 species from the Straits of Mackinac area (Cheboygan, Emmet, Mackinac, and Presque Isle counties). Detailed descriptions of those species, as well as a key for their determination, will be provided in a manual of the bryoflora of the Straits region now in manuscript. Charlevoix County, lying immediately southwest of this group of counties, on the shore of Lake Michigan, was selected for special study in the summer of 1969 because of ease of access from the Biological Station and because not a single record of *Sphagnum* is noted from that county in Darlington's recent *Mosses of Michigan.* We made several trips to the county and found 15 species in the localities listed below (and subsequently referred to by number only). All of these are also known from the Straits counties, which have a *Sphagnum* flora of 25 species, as compared with a total of 27 known from the entire state and about 45 from all of North America.

1. SE ¼ sec. 31, T33N, R7W, Monroe Creek, about 2 miles west of the south arm of Lake Charlevoix, in a dense, ecologically immature *Thuja-Larix* swamp.
2. SW ¼ sec. 10, T32N, R4W, south of county road 626, in an open, sedgy *Larix* swamp with many trees dead because of alteration of the water table by road building.
3. SW ¼ sec. 31, T33N, R7W, Monroe Creek, about 3 miles west of the south arm of Lake Charlevoix, in a seepage area in a *Fraxinus* swamp.
4. NE ¼ sec. 25, T33N, R6W, about 1.5 miles northeast of Boyne City on Highway M-75, in an open, disturbed *Thuja-Larix* swamp (with many trees dead owing to disturbance of the water table).
5. NW ¼ sec. 29, T33N, R4W, south branch of Spring Brook, on Major Road, in a mature *Thuja* swamp.
6. SE ¼ sec. 35, T33N, R4W, 1 mile north of county road 626, on Magee Road, in a partially drained *Larix-Betula-Vaccinium* swamp.

S. capillaceum (Weiss) Schrank var. *capillaceum* 1, 2, 4, 5, 6. Var. *tenellum* (Schimp.) Andr. 4.

S. centrale C. Jens. 1, 2, 5, 6.

S. cuspidatum Ehrh. ex Hoffm. 6.
S. fimbriatum Wils. ex J. Hook. 1, 6.
S. fuscum (Schimp.) Klinggr. 2, 4.
S. girgensohnii Russ. 1, 4.
S. magellanicum Brid. 6.
S. majus (Russ.) C. Jens. 6.
S. recurvum P.-Beauv. var. *recurvum* 6. Var. *tenue* Klinggr. 1, 2, 4.
S. riparium Ångstr. 6.
S. russowii Warnst. 1, 5, 6.
S. squarrosum Sw. ex Crome. 6.
S. teres (Schimp.) Ångstr. ex C. Hartm. 1, 6.
S. warnstorfii Russ. 1, 2, 3, 4, 5.
S. wulfianum Girg. 1.

A full set of specimens is deposited in the herbarium of the University of Michigan Biological Station.

All the species listed here are common and widely distributed, except for *Sphagnum riparium,* which is rare and local over a broad range including northern Europe and Asia, Greenland, Labrador to British Columbia, southward to New Hampshire, Quebec, Ontario, and Michigan. Although it has not been reported previously from Michigan, it has been collected in the past few years in several Michigan localities: Charlevoix Co. (on Magee Road, 1 mi. north of county road 626, *W. M. Zales 892,* UMBS, MICH); Emmet Co. (Stutsmanville Bog, *N. G. Miller 4547,* UMBS, and *W. S. G. Maass,* July 27, 1967, MICH); Iron Co. (Teepee Lake, *R. Harris 725,* MSC); Luce Co. (Rat Lake, *H. Crum,* June 27, 1968, UMBS); Otsego Co. (junction of Gibbs and Marquardt Roads, *H. Crum,* Aug. 7, 1969, MICH); Schoolcraft Co. (0.3 mi. west of Luce County line on Michigan Highway 28, *W. S. G. Maass,* Aug. 3, 1967, MICH).

S. riparium occurs in moderately acid or somewhat basic situations, in relatively wet boggy habitats, especially at the margins of bog ponds, in black spruce bogs and *Thuja* swamps. This is a distinctive species, easy to recognize. The plants are large and green or whitish-green and resemble *S. recurvum* in many ways but may be distinguished by a large terminal bud and stout, turgid branches with broad, imbricated leaves narrowed to a small, recurved tip and not undulate. The leaf tip consists of uniformly narrow, green cells, rather than the usual network of green and hyaline cells. The most striking feature, however, is the large stem leaves (about 1.6 mm long as compared with 1 mm in *S. recurvum*) which are conspicuously perforated or deeply split at the middle owing to localized resorption of the walls of hyaline cells.

We are indebted to the National Science Foundation for funds from Grant GB 8440, made available to the senior author through the Biological Station, and for Grant GB 6095, provided to the junior author for Workshops in Bryology.

A BOTANICAL INVENTORY OF SANFORD NATURAL AREA. I. THE ENVIRONMENT

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"We can never have enough of Nature."
Thoreau in *Walden*

Sanford Natural Area is one of the few local remnants of the great forests which once covered most of southern Michigan. For over a century it has served as an outdoor laboratory for faculty and students of Michigan State University. It has been the subject of forestry research in timber, firewood, and maple syrup production, fire protection, and recreation management. Urbanization of the campus necessitated transfer of this research to less populated areas, but at the same time vast increase in University size has intensified the need for natural areas convenient for teaching. Thus Sanford Natural Area now serves as a major instructional resource for introductory courses in biological science and such upper level courses as plant taxonomy, ecology, invertebrate zoology, ornithology, entomology, and biogeography.

Among the major universities Michigan State is perhaps unique in having a highly diversified woodland conveniently located for efficient use by classes. This very convenience poses the greatest threat to Sanford as a natural area, for in recent years its periphery has been a choice residence hall building site. With the greatly increased student population have come uses and abuses which may ultimately destroy it unless effective protective measures are instituted.

Ten other areas on the University campus, amounting to some 324 acres, are wooded and in varying states of naturalness. None of the others, however, is as conveniently located for most instructional programs as is Sanford. It is also doubtful that any of the other woodlots have a comparably rich flora. Nor are they yet so seriously endangered as Sanford, although encroachment on Baker Woodlot has just begun with construction of the first part of a new medical school complex along its east side.

A principal aim of this account is to record some of the values of Sanford Natural Area. Any observant person might perceive it as an unusual feature of the campus landscape. But its scientific legacy, utility, and potential are not immediately evident to the layman. Hopefully, the information summarized here will provide a basis for greater appreciation of this remarkable resource by faculty, students, and the public. Its preservation will require the concern and cooperation of the entire community. If indeed it can be saved, it could become an outstanding case history on the conservation of a natural area in the face of steadily increasing population pressures.

Another aim of the study is to provide a thorough documentation of one aspect of the Sanford environment—its vascular plant flora. A detailed understanding of the composition of natural environments is fundamental to

any consideration of environmental quality control and rehabilitation. The enormous species diversity of Sanford Natural Area and the unusual nature of many of its species can provide challenging lessons to the student of environmental quality.

My interest in the woodlot began when I first saw it in 1956. At that time *Claytonia virginica* was in full bloom, a beautiful pink carpet of delicate spring wild flowers. I shortly came to depend on Sanford for three courses, but not until I began teaching a large new course in introductory plant taxonomy in 1964 did its instructional value become most evident to me. All of the nearly 250 students annually enrolled in this course have an opportunity (in small groups of about 16) to study the Sanford flora. The checklist of vascular plants (to be published in the next issue of *The Michigan Botanist*) started as a limited list for use in the course. By 1968 so many species had been added that it was evident an intensive and systematic search ought to be made. Field trips were conducted that summer at two- to three-week intervals, each adding 30 or more new records for the Area. Although the present list of 358 species should be nearly complete, we have continued to find additional species up to the time of this writing (November, 1969). There may also be species added, chiefly weedy ones, which are not now in Sanford. Likewise there may be subtractions, as there have already been, but I fervently hope the many uncommon native plants can be preserved.

PHYSICAL SETTING

Sanford Natural Area (Fig. 1, Fig. 2) is located in the S½ of the SE¼ of Sec. 18, T 4 N, R 1 W of the Michigan Meridian, Ingham County, on the Michigan State University campus, immediately south of the Red Cedar River, between Hagadorn Road on the east and Bogue Street on the west. It is bordered by dormitories on the west and south. It formerly included 55.5 acres, but was reduced to 35 by building and road construction between 1956 and 1965.

The land surface slopes generally toward the river, but two levels of benches are apparent on the topographic map (Fig. 1). The soils on these benches (Fig. 3) commonly differ from those on the lower lying alluvial areas which are subject to periodic flooding by the Red Cedar River. Natural soil drainage is good on the highest bench, above elevations of 840 feet, where Oshtemo loamy sand predominates. The lower bench of Metamora soils is less well drained, and drainage is poorest on the alluvial Ceresco soils. The natural levees of Landes soils along the river are better drained. Elevation of normal water level at Bogue Street Bridge is 829 feet, and extreme high water level at that location is 836.5 feet. Maximum elevation in the woodlot is 852 feet.

The well drained or zonal soils of Ingham County belong to the suborder of Udalfs in the New Comprehensive Soil Classification in the United States (Soil Survey Staff, U.S.D.A., 1960 et seq.) and are represented in Sanford Natural Area by the Oshtemo and Lapeer series. These were formerly the Gray-Brown Podzolic soils of Central and East-Central parts of the United States (Veatch et al., 1941; NCR. 3 Committee, 1960).

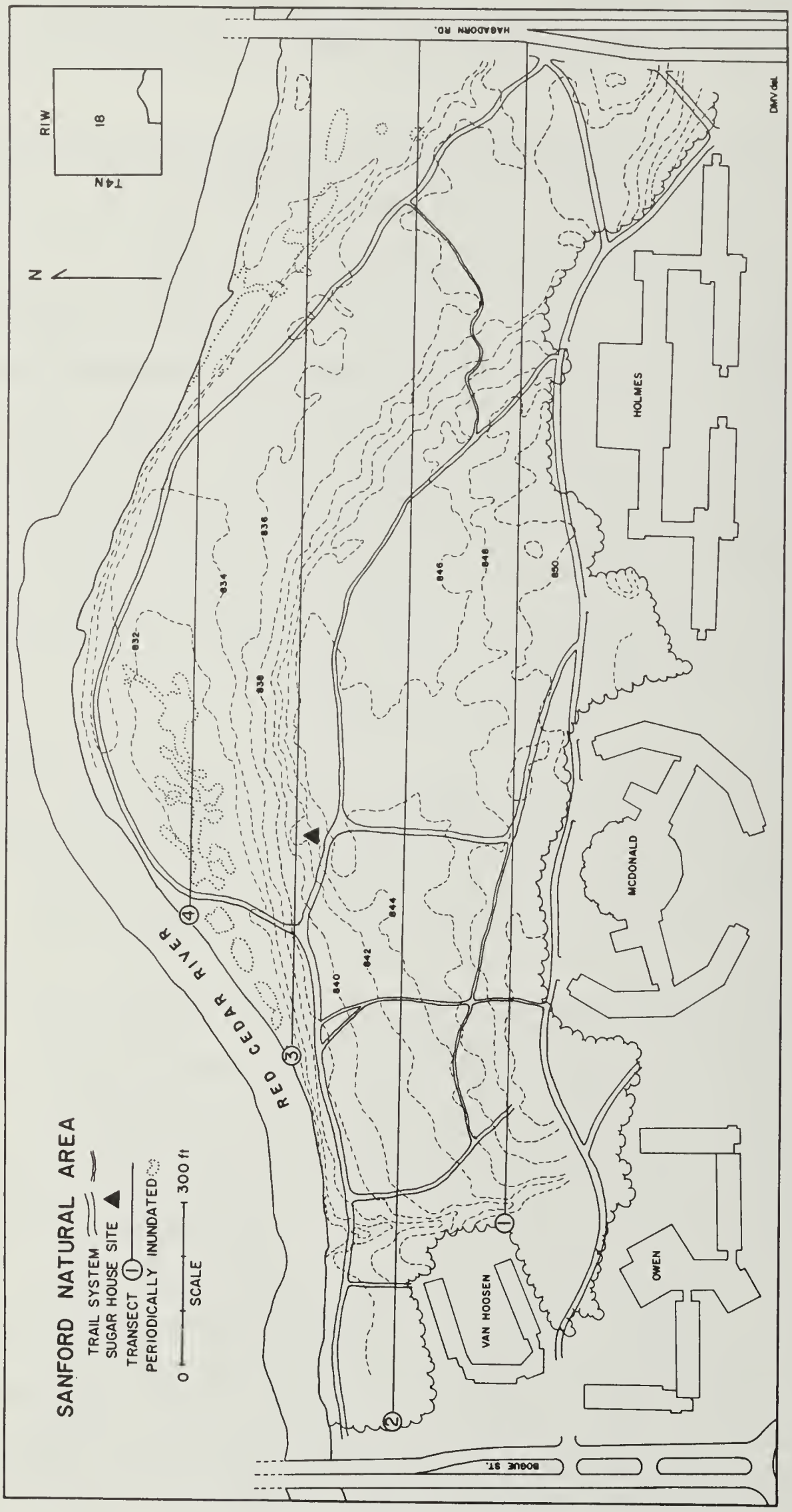

Fig. 1. Topographic map of Sanford Natural Area, based on 1965 revision of blueprint by Division of Physical Plant Planning and Development, Michigan State University. (The narrower trails have developed from recent usage.)

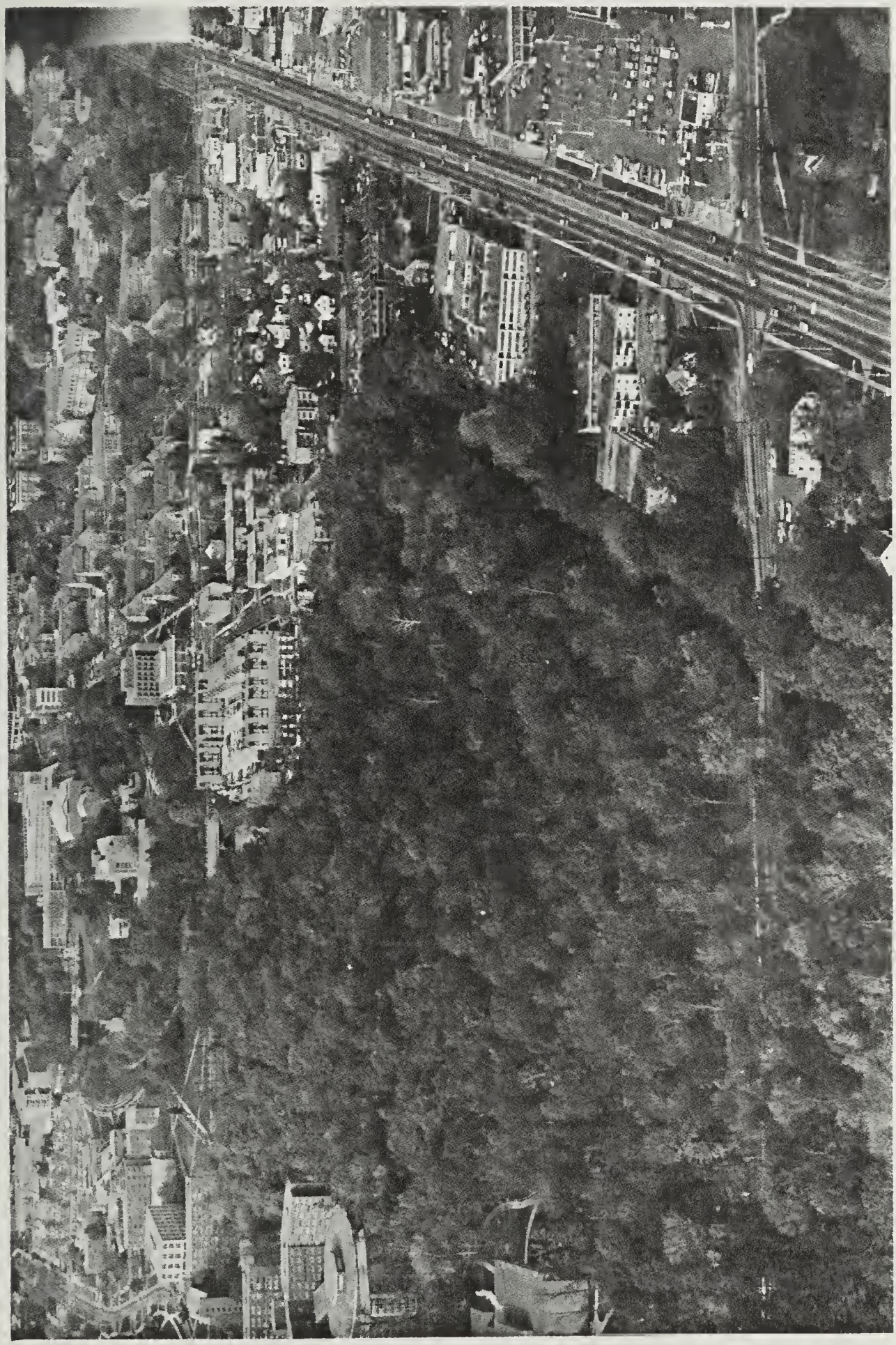

Fig. 2. Oblique aerial view of Sanford Natural Area from the east. Most conspicuous, partly circular building at left is McDonel Hall; Bogue Street Bridge is slightly left of center in upper portion of photo; Grand River Avenue is at the right; Hagadorn Road parallels bottom. Photo by D. E. Webb, October 29, 1969.

Average annual precipitation in the East Lansing-Lansing area for the period 1864-1968 was 30.84 inches, with a maximum of 48.44 inches in 1883 and a minimum of 18.50 in 1930. For the 30-year period from 1931-1960 the greatest monthly rainfall was in May (3.73 inches), June (3.34 inches), and August (3.05 inches); the least in December (1.99 inches), January (1.96 inches), and February (1.95 inches). For the same period the average daily maximum temperature was 57.1° F and the average daily minimum 38.2°, with an average annual temperature of 47.6°. The average daily maximum for this period was highest in July with 83.4° and the average daily minimum was lowest in February with 16.5°. (Data from the Environmental Science Services Administration, State Climatologist, East Lansing.)

According to Westveld (1931) and an unsigned, undated report in the Forestry Department, records (not seen) made by Dr. W. J. Beal show that about 150 trees, especially beech, died as a result of the drought of 1894 and 1895, with destruction greatest on the west side of the woods. Similarly, the death of 48 trees, about half of which were beech, was attributed to the drought of 1934 (unsigned report of January, 1936, in the Forestry Department). These appear to be the only written records which suggest that recent climatic fluctuations have adversely affected the Sanford vegetation.

Apparently climatically related effects are evident, however, on radial growth as shown by increment cores from trees in the Area (11 species, 18 trees, listed in Table 3). The earliest records obtained from the cores indicate an adverse period in the early 1870's. This was followed by a period of mostly normal growth until the late 1880's when another adverse period began which lasted to the mid-1890's. In a subsequent period through 1923 optimum conditions for growth prevailed. Normal growth for some trees and slow growth for others followed until the early 1930's. An especially adverse period from this time until the late 1940's is indicated by most trees in the sample. Relatively normal growth rates have prevailed in about half the sample from that time to the present, although the early 1960's was a time of slower growth for several species. These times of slow, normal, and rapid growth correspond for the most part with cumulative precipitation for the same periods.

There was an average precipitation deficit of two inches per year from 1867 through 1875, a deficit of nearly four inches per year from 1888 through 1895, a deficit of two inches per year from 1930 through 1939, and a deficit of nearly five inches per year from 1960 through 1966. The principal failure in correspondence of growth rates and precipitation is from 1940-1949 when there was a three-inch average annual precipitation excess for the decade but the majority of the trees in the sample grew more slowly than normal. This might possibly reflect a slow recovery from the drought of the 1930's, but other factors could be involved. The limited data from the increment cores and the observations of trees dying during droughts suggest that, even in this area of relatively high rainfall, precipitation may often be a major factor in growth rates or survival of trees.

Fig. 3. Map of Sanford Natural Area showing wards, firebreak, and trails from map of 5 November 1895; soil boundaries from map by A. J. Quinkert with the advice of J. O. Veatch, c. 1931, revised in 1969 with tentative correlations by E. P. Whiteside; Ca, Carlisle muck; Ce, Ceresco fine sandy loam; Gr, Granby sand; Lan, Landes fine sandy loam; Lap, Lapeer sandy loam; Me, Metamora loam; Os, Oshtemo loamy sand.

ADMINISTRATIVE HISTORY

Sanford Natural Area is part of 676.57 acres of forested land purchased in 1855 from A. R. Burr of Lansing as the site for the Agricultural College of the State of Michigan. Within 40 years all but 150 acres had been cleared for buildings and fields. On December 11, 1894, the State Board of Agriculture passed a resolution introduced by Charles Garfield, Chairman of the Committee on Botany and Horticulture, to the effect that College policy would be to preserve and place all remaining forest areas on the College farm in such a condition as to illustrate good woodlot management for continuous and lasting crops. The woodlots were placed under the supervision of the professor of agriculture who managed them under the guidance of the professor of botany and forestry. On August 28, 1901, the Forestry Department was established and charged with management of the woodlots.

One of these was originally called North Woodlot and Woodlot No. 1. It was later named River Woodlot, the name in general use in the 1930's. In 1941 Professor Paul A. Herbert, then Head of the Forestry Department, renamed it Sanford Woodlot, after Frank Hobart Sanford (1880-1938; B.S., 1904; M.S., 1913; Forestry faculty, 1906-1920; the second full-time forester appointed by the College).

On December 11, 1959, President John A. Hannah transferred jurisdiction of Sanford Woodlot from the Forestry Department to Campus Planning and Grounds Maintenance (now Division of Campus Park and Planning). In 1964 the name was changed to Sanford Natural Area, to better reflect the purposes to which it is currently dedicated.

Over the protests of numerous Michigan biologists and conservationists a new era in its history began in 1956 when about two acres on the west side were taken over for construction of a women's cooperative residence hall (Van Hoosen). Since that time three other residence units (Owen Hall, 1960-65; McDonel Hall, 1963; Holmes Hall, 1965) have been built into the west and south sides. Bogue Street Bridge (west side) was built in 1964, and Hagadorn Road (east side) was widened in 1965. This construction reduced the size of the Area by about 20 acres, obliterated at least one major habitat, and eliminated several species from the flora.

In 1895 the woodlot was subdivided into six wards (Fig. 3), each containing approximately 10 acres (Smith, 1896). The purpose of the subdivision was for designating and recording conditions of the different portions of the forest and work performed upon them. At this time a general clean-up was made to remove debris and fallen trees. A firebreak four rods wide north and south through the center of the woodlot was cleared of all underbrush, old logs, and leaves. This strip was not kept up very long, however, since there was no evidence of its existence in 1931 (Westveld, 1931). While brush from the clean-up was being burned in the spring of 1895 fire escaped three times and burned approximately 15 acres, mostly in Wards 1 and 2 but also near the north end of Wards 4 and 5. There apparently are no more recent records of fire in the woods.

Cattle have always been restricted from the woodlot. The basis for this was stated by Crozier (1896):

> Two principal enemies of forest property are live stock and fire. Where stock is confined to a limited section of woodland all underbrush is soon destroyed and the woods became open and park like, the surface more or less covered with grass, attractive places for picnic parties, etc., but of little further use as a forest. The duration of such a forest is necessarily limited to the life of the large timber, and even this often prematurely dies from the unwonted exposure.

To the principal enemies of forest property noted by Crozier we must now add the excessive human population.

HARVESTING OPERATIONS

The forest is of mostly natural origin and uneven age, but it is by no means virgin as some people seem to think. It was managed for 65 years to demonstrate sound forestry practices for farm woodlots. Prior to that time a considerable number of trees in certain areas had been cut for fuel. During the management period harvest cuttings were both selective and conservative. A major objective was maple syrup production, so virtually all trees of *Acer saccharum* were spared. According to Crozier (1896) the large timber was cut from several acres in one ward (Ward 1) a few years prior to 1896, and a thrifty second growth took its place. In the fall and winter of 1896-97 about 150 dead or dying trees were converted into fuel wood. In 1912 one acre in the northeast corner was selected as a practice field for silviculture students doing thinning operations (Walline, 1940). During the winter of 1931-32 all dead timber was cut, amounting to 100 standard cords of fuel wood. A salvage cutting was made in 1936 to remove 48 trees which had been killed by the drought of 1934. Westveld's (1931) management plan indicated that almost the entire woodlot would be given a selection cutting in 15 years, but the cutting was to be restricted principally to trees 12 inches d.b.h. and over. It is not clear from the records that this policy was implemented, but a portable sawmill was located in the woodlot from 1934 to 1948, so it may be assumed that considerable cutting was done. The lumber manufactured was used by various departments, partly for building construction, and for the annual Winter Carnival. The firewood produced was used for evaporating maple sap, with the excess being sold to local residents and commercial companies. The last harvest by the Forestry Department was in 1959.

MAPLE SYRUP PRODUCTION

The woodlot was first used for syrup production in 1915, at which time an evaporator house (referred to subsequently as "sugar house") was erected and equipped with a Leader Evaporator. The trees were tapped for the last time in 1960, and the sugar house shortly removed, but its site remains a distinctive part of the woodlot (see p. 134). Early research efforts in syrup production concerned the effect of varying numbers of buckets on sap flow. This research was gradually broadened to include other problems related to the operation of a sugar bush, such as fertilizer effect on the yield of syrup,

the effect of cultural operations on sap yields, and financial aspects of operating a sugar bush (Anonymous, 1953). Walline (1940) reported that there were ca. 748 sugar maple trees large enough for tapping (12 inches or greater d.b.h.) in the entire woodlot, but only 600 were conveniently situated for tapping. The average yield per tree based on a nine-year record between 1915 and 1925 was 0.2 gallons of syrup. The highest yield secured was 0.34 gallons per tree. During this period 1,050 gallons of syrup were produced with an average annual yield of 116.6 gallons.

RECREATION MANAGEMENT

The recreational values of Sanford Natural Area have been recognized since management procedures were first instituted. Crozier in 1896 noted that the roads and other improvements were making it a forest park which was becoming a popular resort for students and others. The management plans prepared by Westveld (1931) and Walline (1940) indicate that the area was to be maintained in a condition suitable for recreation. As early as 1931 keeping cars off the trails was a problem, a circumstance now paralleled by the prohibited but all too frequent motorcycles. For a number of years certain trails were part of the bridle trail system, but not all riders managed to keep their horses on the trails. Partly because of this abuse the woodlot was closed to equestrian travel in 1949. Certain trails have been in use for many years by the cross-country track team. About 20 years ago the road near the river was made into a nature trail, with labels identifying the plants (Wilcox, 1949). This was not maintained very long, however, and by 1969 only one label was still evident. In spite of the recent unsightly apartments on the north side of the river, Sanford contributes much to the attractiveness of canoeing, a currently popular pastime on the Red Cedar. It also serves as a pleasant buffer between the campus and the apartment and business district to the north.

The most important recreational use of Sanford Natural Area is also the most difficult to document. Thousands of people live in its vicinity. Some probably care nothing for it and may even resent its presence. Many others, however, do appreciate it as a place they can go on a pleasant day and enjoy nature. Persons who have grown up in the East Lansing area have often remarked to me of fond memories of childhood outings in the woodlot.

The recreational and cultural values of natural areas have been forcefully expressed by Iltis (1968): "We need nature and its diversity in order to survive as human beings, as well as a technological and agricultural civilization. We must, therefore, accept that *nature is the most precious of all human possessions.* Our educational system's main responsibility, therefore, is to train people, not only in the exploitation, but now also in the protection of nature—the only nature to which man is adapted, in which man can exist."

SANFORD AS AN INSTRUCTIONAL LABORATORY

A summary of current use of the Area for formal instruction in 21 courses is presented in Table 1. Obviously not all class time for a particular course is spent there, but it is nevertheless a basic resource for these classes.

TABLE 1. Courses currently using Sanford Natural Area as a laboratory, grouped by departments as follows: Biological Science, Botany and Plant Pathology, Entomology, Fisheries and Wildlife, Forestry, Geography, Lyman Briggs College, Zoology.

Course	Approximate no. of students per year
B S 202, Foundations of Biological Science	450
BOT 318, Introductory Plant Taxonomy	250
BOT 450, Ecology	5
BOT 823, Plant Taxonomy	10
ENT 302, General Entomology	30
ENT 420, Aquatic Insects	40
ENT 438, Taxonomy of Immature Insects	7
ENT 820, Insect Ecology	7
F W 402, Conservation Education	100
F W 403, Conservation Education	100
F W 483, Advanced Conservation Education	15
FOR 302, Forest Biometrics	36
GEO 411, Problems in Geography	10
GEO 431, Advanced Physical Geography	10
GEO 432, Biogeography	20
LBC 140, Biology	250
ZOL 204, Natural History of Birds	17
ZOL 461, Ornithology	50
ZOL 481, Invertebrate Zoology	60
ZOL 486, Mammalogy	10
ZOL 881, Biology of the Arthropoda	12
TOTAL	1,489

Other important instructional values of the woodlot are less tangible. For example, many of the more advanced students in plant taxonomy have done their first fieldwork there, as an examination of collection numbers in the checklist will demonstrate. The amount of instructional use the Area can sustain is naturally somewhat limited; a class of 450 students cannot be turned loose to forage at will. But divided into small groups of 10 to 20, which stay on the ample trails, a large class can use the area without undue damage. All classes are expected to avoid picking flowers, breaking shrubs, trampling the soil, or otherwise altering the natural environment.

The opportunity for special training and research which the woodlot offers is illustrated by several undergraduate and graduate students currently working in the Beal-Darlington Herbarium who are developing procedures for computerizing floristic data. They have already prepared preliminary taxonomic data matrices for the woody species, herbaceous spring dicots, and spring monocots of Sanford. These data matrices will be used in connection with the teaching program in introductory plant taxonomy.

Although University students are the principal users of the Area, it is noteworthy that secondary schools in East Lansing are also taking classes there.

PLANTINGS

On several occasions native and exotic species have been planted in the woodlot. The most ambitious attempt was in 1896, a description of which is provided below (from an unsigned, undated report in the Forestry Department; cf. also Crozier, 1897; cf. Fig. 3 for trail locations and ward boundaries).

> In this woodlot were planted in the spring of 1896 the following seeds and young trees. The nuts and acorns were furnished by Dr. W. J. Beal, also the young redbuds and black locust sprouts. The locusts, about fifty in number, were set in Ward 1 between the crossroad and the ravine. The redbuds, a dozen or more, were mostly set on the river bank in the lane from two to ten rods west of the woods. These were one year old from seed. A few chinquapins were planted in the south half of Ward 1, north of the south drive. In the same locality a smaller number of chestnuts were planted, also a few of the same all along the south drive and a group of the same on newly plowed land in the extreme southeast corner of the woodlot where they were protected and cared for during the season and made a good start. Some of the chinquapins were in poor condition when they were planted here. In Ward 1 in the same general locality as the chinquapins, north of the south drive, were planted about one fourth of a bushel of shucked walnuts. About the same amount of hickory nuts were planted in a thin spot in the south end of Ward 3 where there stands a tree of the same species about ten inches in diameter. About half a peck of butternuts was planted in the same general locality but mostly further south and more scattered. A few red oak acorns were planted in Ward 1 along the sides of the crossroad and near its north end. Also a large number of red oak acorns were planted along both sides of the drive across the north end of Ward 4. In the north end of Ward 3, near a large tree of the same species were planted about two quarts of bur oak acorns. About the same quantity of swamp white oak acorns were planted along the bayous in the north end of Wards 3, 4 and 5. About a dozen nuts of *Carya porcina* [= *C. glabra*] were planted in Ward 2 south of the south drive about four rods west of the point of its greatest northerly bend. They were planted in open places in a belt about eight rods long north and south.
>
> At the right of the drive just after entering the woods from the river lane were set three pawpaws taken from the opposite bank of the river. Along the south side of the lane were set four groups of trees native to Michigan, deciduous trees all from the neighboring river banks, woods or elsewhere on the farm. The conifers were furnished by the Horticulture Department and were from where they had been grown a few years in the nursery row. At the right of the entrance leading from the main farm lane were set a mixed group, including hard and red maples, basswood, tulip, red alder, Juneberry, hazel, red cedar, arbor vitae, and white pine. All made a good start during the season except the Juneberry. The white pine was a large spreading tree about five feet high, the larger of the two red cedars was four to six feet high and the two arbor vitae each about two feet high, though one of them was partly broken down during the summer. On the steep side of the river bank opposite this group, were set two red cedars of about the same size as those set in the group. Further east on the next rise was set a large group of deciduous trees including three species of elm, beech, hawthorn, Juneberry, and ninebark. On the next rise of land to the east was set a group of prickly ash, and a little further east on swampy ground which is now drained where the line fence begins to run straight were set four thrifty young cedars of the same size and from the same source as the two set in the first group at the west end of the lane.
>
> Along the river bank just west of the bridge to the east side of the little stream coming down out of Ward 1, were set, chiefly in the woods, ten red cedars

12 to 18 inches high. By the lagoon, just east of the firebreak, were set ten arbor vitae about 12 inches high. On the south river bank just west of the bridge, were set two white spruce, eight or more of the same being set just north of the south drive in Ward 1. They were about two feet in height. Those in the woods were badly eaten by squirrels soon after being set and made a poor start. At the angle between the north and the cross drive were set eleven white pines, mostly misshapen or injured in some way but vigorous and four to six feet high. These were obtained from the Horticulture Department.

In the east end of the same woodlot in the vicinity of the gates into the highway were set ten red pines about three feet high. In Ward 5 on the margin of an old gravel pit were set about ten hemlocks and in Ward 2 on the north side of the north drive about twenty more of the same species were planted.

Of the species planted in 1896, the only ones known with certainty to have survived to 1969 are about a dozen black locusts (the largest now 21 inches d.b.h., but most of them 9-12 inches) and four hemlocks (5-8 inches d.b.h.). A chestnut persisted until Van Hoosen Hall pre-empted its space.

In addition to the planting program of 1896, four bushels of black walnuts were planted in the southeast corner running over into Ward 3 in November, 1904, and in December of that year a part of four bushels of butternuts were planted in Ward 2 and also running north and south across Ward 1. Much more recently, subsequent to the construction of Holmes Hall, shrubs or small trees of *Halesia carolina, Tsuga canadensis, Thuja occidentalis,* and *Cornus controversa* have been set out on the southeast edge of the woods.

THE FOREST IN 1895

The following notes (reproduced in an unsigned, undated report in the Forestry Department) were recorded in October, 1895 (cf. Fig. 3 for trail locations and ward boundaries).

Ward 1. Original timber was mainly beech and maple. The larger trees have more than half of them been cut from time to time and along the west side the wind has blown down most of them that were left. On the west side next to Field No. 7 a strip about ten rods wide is covered with a continuous thicket of young trees ten to fifteen feet high. Further in, the second growth is smaller and occurs more in clumps with comparatively open spaces between. The larger timber consists of the following species: At the north end along the river are a few basswoods, four at least over one foot in diameter; four tall bitternuts of about the same size as the basswood; three white ash one foot or more in diameter; three red elm respectively of six inches, one foot, and one and a half feet in diameter. On the line in the northeast corner of the ward and one rod from the river bank is a fine large maple six feet, ten inches in circumference at four and a half feet from the ground and several others nearly as large, consisting of maple and beeches. One rod from the bank and about one third of the way to the west side of the ward is a tall thrifty butternut 45 inches in circumference, four feet from the ground.

Further south in the ward the following other trees were noted: Several bitternuts, one red elm, one rock elm, one white ash, one butternut, one black cherry, one scarlet oak [in this account scarlet oak probably is *Quercus rubra* var. *borealis*], and about a dozen basswoods. Several of the beeches in the southwest corner of the ward are dead and others dying, with frequently the upper half only of the trees being affected. A large share of this injury has occurred from drought this season.

Near the river is a mulberry stump from which a sprout is growing fifteen inches in circumference. This stump is 44 inches in circumference. The undergrowth of this ward consists of the following species grouped as shrubs and trees and arranged in about the order of abundance.

Trees. Sugar maple—the most abundant. American elm, white ash, mainly at the south end. Beech, ironwood, in the center. Blue ash in the southwest quarter. Red elm in the north half. Rock elm in the south half. Bitternut, red maple, mulberry, basswood, black walnut, all small, butternut sapling, and white oak.

Shrubs. Spice bush, blue beech, red elder, American ivy, choke cherry, bladdernut, moosewood, green osier, hawthorn, wahoo, gooseberry, black raspberry, blackberry, witch hazel, poison ivy, prickly ash, greenbrier, red osier.

Ward 2. Similar to Ward 1 with the following exceptions: Beginning at the south end was noticed a few clumps of sumac, some small trees of black cherry, a few saplings of white, scarlet and black oak, also younger oaks eight to twelve feet high, chiefly white oak, several sassafras ten to fifteen feet. The undergrowth is chiefly sugar maple. On the north half of the Ward are several tall ironwoods. Near the northwest corner immediately on the river bank and leaning a little toward the river are two scarlet oaks about three and a half feet in diameter. A smaller tree of the same species stands about four rods further east. The undergrowth here for about six rods back from the river is about eight feet high and chiefly beech.

In the northeast corner is about half an acre of bottomland in which are a white ash 49 inches in circumference, a butternut 75 inches, two American elms respectively 97 and 84 inches, two scarlet oaks respectively 45 and 71 inches, these all being on the immediate river bank. Then on the lower land a little further back are white ash 86 inches and a red elm 46 inches in circumference.

Ward 3. At the north end the bottomland widens eastward and the ridge along the river broadens and becomes more pronounced in the same direction. In the northwest corner of the ward, beginning at the corner stakes, are first a small, diseased and crooked butternut, a second thrifty leaning sycamore about two feet in circumference with a large dead spot at the base on the northeast side, caused apparently by fire about four years ago. Other trees are a double sapling butternut, four thrifty bur oaks about three and a half feet in diameter. The open ground on the bottomland is covered with poison ivy.

About midway east and west in this ward the road crosses the lower land to the bluff along the river. In the center of the low land at the edge of the road on the west side is a hickory about ten inches in diameter, and on the opposite side a thicket of young black ash six to ten feet high.

On the east side of the road just as it strikes the bluff are two Kentucky coffee trees now seven feet high which have grown as sprouts from small trees that had been cut down. These two trees were cut down again by hunters in 1896. The timber on the river ridge on the east half of this ward consists mainly of half-grown maples six to ten inches in diameter. Down on the river edge is a fringe of larger white maple, while scattered over the ridge are beech, white ash, red and rock elm, ironwood, basswood, and sassafras. Two beeches and one scarlet oak are of large size.

In the bottomland and extending east across the firebreak into Ward 4 is a lagoon or series of lagoons now dry bordered by a mixed undergrowth chiefly of black ash and white maple with a few tall thrifty trees of the same species.

South of this bottomland the remainder of Ward 3 consists of a better class of timber than Ward 2, it being taller and more thrifty, the maples rather exceeding the beech in number except at the south end where the large timber is mainly beech. The timber, especially through the center of the ward is quite open, having been much of it cut for fuel and the ward as a whole possibly containing no more large timbers than in Ward 2. The entire upland of this ward is covered with young growth five to ten feet high and becoming at places very thick and some of it is

from ten to fifteen feet high. Hard maple prevails except on a strip about five rods wide along the top of the bluff where it is nearly all beech. A tall thrifty butternut about one and a half feet in diameter was noted near the bluff and a solid top of the same species over two feet in diameter south in the edge of the firebreak. Several young butternuts are scattered through the ward and at the south end are young trees of sassafras, poplar, sumac and white oak, mixed with the sugar maple and white oak.

Ward 4. Timber on this ward is more uneven and at the south end the oldest timber consists still more largely of beech than Ward 3. Much of the small growth at the south end of the ward is red maple and dogwood. The southeast corner of this ward is the head of a swamp, which opens toward the east. In this swamp is a thicket consisting of red raspberry, red osier, black alder, poison sumac, and several species of willow. In the open ground on the margin of the swamp *Osmunda regalis* is abundant. On the bluff north of the swamp on a line between Wards 3 and 4 is a continuous thicket of beech, maple, etc., four to five feet high which becomes thicker and taller further north. In this undergrowth are also sassafras, maple-leaved viburnum, dogwood, witch hazel, red maple and several species of oak.

The central portion of this ward contains but little large timber, most of it having been cut for fuel. What is left is mainly beech. The surface here is entirely covered with second growth, thicker than in any previous ward. On the bluff on a line between this ward and Ward 5, is an especially fine mixture of maple.

Ward 5. The swamp which began on Ward 4 extends across the entire south end of this ward and a short distance into Ward 6. It also extends a little south over the line fence. In this swamp are about two dozen tamaracks ten to fifty feet high and with several still smaller types. The swamp is mostly filled with willows, ash, poison sumac, etc., but at the outlet, which is just across the line in Ward 6, there is south of the road an open marsh of about one fourth of an acre and another of smaller size in the southwest corner of Ward 6. The water from this swamp discharges across the road above mentioned and loses itself in the woods to the north. North of the swamp in Ward 5 just north of the road which is the south drive is a gravel pit from which a large amount of excellent red gravel has been taken for the public highway.

Ward 6. The south end of this ward is thinly timbered, chiefly with low-headed thrifty beeches and a few tall large maples. The surface is mostly grassed over and bears thin, scattered clumps of beech four to six feet high. At the north end river bottom occupies about one fourth of the entire ward and most of this bottomland consists of a broad swell or ridge near the river. This ridge bears a mixed growth of tall young timber, much of it about one foot in diameter, consisting of three kinds of elm, butternut, black cherry, ironwood, beech, maple, basswood, hickory of the bitternut variety, rock and red elm prevailing. On the low land south of the ridge is a miscellaneous thicket of undergrowth. The rock and red elm seems to prevail.

PRESENT FOREST STRUCTURE

In October, 1969, the occurrence and distribution in Sanford Natural Area of woody species of tree growth form were analyzed using the point-quarter method (Cox, 1967). Data for individuals one inch or greater d.b.h. at 100 random points distributed along four transects (cf. fig. 1) were recorded and are summarized in Table 2. The importance values were obtained by summation of relative density, relative dominance (basal area), and relative frequency values. From these data it is evident that *Acer saccharum* is by far

TABLE 2. Density, basal area, relative dominance, frequency, and importance values of 27 woody species one inch or greater d.b.h. encountered at 100 point-quarters in Sanford Natural Area.

Species	Density (individuals per acre)	Basal area per acre (sq. ft.)	Relative dominance (%)	Frequency (%)	Importance value
Acer saccharum	436.9	81.03	62.9	74	137.4
Fagus grandifolia	67.2	20.46	15.8	24	32.2
Acer saccharinum	62.4	14.86	11.5	14	23.4
Fraxinus americana	72.0	3.28	2.5	25	19.8
Tilia americana	43.2	3.08	2.3	25	16.6
Acer nigrum	52.8	2.54	1.9	18	14.4
Carpinus caroliniana	43.2	0.26	0.2	15	10.5
Ostrya virginiana	38.4	0.17	0.1	14	9.5
Ulmus americana	30.7	0.91	0.7	12	8.6
Quercus rubra var. *borealis*	24.0	1.58	1.2	9	7.2
Fraxinus nigra	7.7	0.00	0.0	3	1.9
Quercus muehlenbergii	7.7	0.18	0.1	2	1.6
Quercus macrocarpa	5.8	0.10	0.1	2	1.3
Prunus serotina	4.8	0.15	0.1	2	1.3
Lindera benzoin	4.8	0.00	0.0	2	1.2
Sassafras albidum	4.8	0.02	0.0	2	1.2
Ulmus rubra	4.8	0.00	0.0	2	1.2
Crataegus mollis	4.8	0.00	0.0	1	0.8
Acer negundo	2.9	0.00	0.0	1	0.6
Acer rubrum	2.9	0.08	0.0	1	0.6
Carya cordiformis	2.9	0.00	0.0	1	0.6
Celtis occidentalis	2.9	0.01	0.0	1	0.6
Crataegus punctata	2.9	0.00	0.0	1	0.6
Hamamelis virginiana	2.9	0.00	0.0	1	0.6
Populus deltoides	2.9	0.00	0.0	1	0.6
Robinia pseudo-acacia	2.9	0.00	0.0	1	0.6
Staphylea trifolia	2.9	0.00	0.0	1	0.6

the most important tree, but nine other species are of considerable significance.

The preponderance of *Acer saccharum* may have resulted in part from its being left for syrup production, while other species were more heavily cut. Sugar maple is a very shade-tolerant species, however, and is now present in large numbers in the small diameter classes. Although it may have been favored by selective cutting, the 1895 account indicates that it was very abundant at that time. The data for sugar maple and beech in Sanford Natural Area are in close agreement with those for Toumey Woodlot, a 15-acre virgin tract on the campus about two miles south of Sanford. For this stand Schneider (1966) reported (on the basis of a 100% inventory in 1960) that there were 400.3 sugar maple trees per acre one inch or greater d.b.h. and 54.2 of beech. All other species he noted were lower in density than the major species in Sanford, except *Ulmus rubra* for which he reported 38.2 trees per acre (his study was prior to the epidemic of Dutch elm disease). It appears therefore

that the trees in Sanford are as densely stocked, if not more so, than in a neighboring woods which is virtually undisturbed.

Distributional patterns of the important trees are not readily apparent from the data in Table 2. The high frequency value of *Acer saccharum* suggests that it is common throughout most of the woodlot. The only place it does not occur is around the intermittent lagoons near the river, where it is replaced by *Acer saccharinum.* The latter is also common on the river margin and is restricted to very wet habitats. The other most important trees, common on both the floodplain and upland, are *Fagus grandifolia, Fraxinus americana, Quercus rubra* var. *borealis,* and *Tilia americana.* Each of them, however, is more abundant in some areas than in others. The relatively slight differentiation of tree distribution in the woodlot makes a small-scale vegetation map impractical. I have been unable to clearly distinguish five forest types which Westveld mapped in 1931.

A recent drastic change in the relative abundance of trees in Sanford (as elsewhere in south-central Michigan) has been caused by Dutch elm disease. In 1961 Dr. G. W. Parmelee examined all the larger elms in the woodlot and found in healthy condition 395 *Ulmus americana* (including a few *U. thomasii*) and 220 *U. rubra* of eight-inch or greater d.b.h. An additional 73 trees were noted which were suspected of harboring the disease. By 1969 almost every elm greater than six inches d.b.h. was dead; only one large tree (24 inches d.b.h.) was found alive. Many of the dead trees are still standing, but others were cut or have fallen and are rapidly decaying.

In addition to the dead elms there is some mortality among other important species. Much of this is the result of wind damage. At present there are 66 trees four inches or greater d.b.h. which have recently fallen or are severely bent or broken. These are as follows:

Species	Number of trees	Basal area (sq. ft.)
Acer saccharum	33	30.55
Fagus grandifolia	4	7.17
Fraxinus americana	8	14.73
Quercus rubra var. *borealis*	3	8.75
Tilia americana	11	14.78
Miscellaneous (6 species)	7	10.17
Total	66	86.15

Much of the damage is in the upland portion of the woods, especially near the south edge. Holes from the root systems of the larger windfalls range from 2-4 feet deep and are generally 8-15 feet across, although one hole 20 feet wide was observed. "Tip-up" mounds from old windfalls are abundant on the upland.

The dimensions, estimated age, and radial growth rate for 18 trees representing 11 species are indicated in Table 3. It is evident that the trees attain most of their height long before they become exceptionally large in diameter. The forest canopy generally ranges from about 85 to 115 feet in total height. One of the tallest and fastest growing trees is *Acer saccharinum.* Several trees

TABLE 3. Dimensions, estimated age, and radial growth of selected trees in Sanford Natural Area.

Species	d.b.h. (inches)	Total height (feet)	No. of annual rings observed	Estimated age[d]	Average annual diameter increment (inches)
Acer saccharinum	34[a]	125	73[c]	130	0.25
A. saccharinum	18	100	86	90	0.22
A. saccharum	37[a]	110	64[c]	210	0.17
A. saccharum	15	70	110[c]	135	0.10
A. saccharum	16	95	110	115	0.14
Fagus grandifolia	29[b]	90	84[c]	150	0.20
F. grandifolia	14	85	77	85	0.16
Fraxinus americana	33[a]	115	90[c]	150	0.21
F. americana	18	95	90	95	0.20
Juglans cinerea	17[a]	85	64	70	0.24
J. nigra	23[a]	75	72[c]	80	0.28
Quercus rubra var. *borealis*	33[a]	95	115[c]	190	0.17
Q. rubra var. *borealis*	16	95	72	80	0.24
Sassafras albidum	18[a]	80	68	75	0.22
Tilia americana	28[a]	110	98[c]	125	0.23
T. americana	19	110	89	105	0.17
Ulmus americana	24[a]	85	258	280	0.08
U. rubra	13[a]	85	67	75	0.17

[a]Largest tree in diameter of this species in the Area.

[b]The largest *Fagus grandifolia* is 30 inches d.b.h. and 125 feet high.

[c]Increment core substantially incomplete (11 inches is the maximum length with the equipment available); all cores taken at 4.5 feet above ground level.

[d]Based on the number of annual rings observed, the completeness of the increment core, and in the case of incomplete cores the d.b.h. (excluding bark) and average annual diameter increment. These estimates do not take into account the possibility that the tree may have existed as a seedling for an extended period.

of this species around the lagoons are between 115 and 125 feet tall. In the central upland 95 to 110 feet is a common height for the larger trees. At the northwest corner the trees are of lower stature, ranging from about 70 to 90 feet, possibly because this is a second-growth stand.

The faster-growing species, in addition to *Acer saccharinum,* include *Juglans cinerea, J. nigra, Quercus rubra* var. *borealis, Sassafras albidum,* and *Tilia americana.* Species with slower growth include *Acer saccharum* (one tree of this species with 37-inch d.b.h. is the largest in the woodlot), *Fagus grandifolia,* and *Ulmus americana.* None of the trees examined had a uniform rate of radial growth throughout the period represented by the increment cores (see p. 120). The most obvious long-term variations involve an extended period of rapid growth from about 1896 to 1923 and a corresponding period of slow growth from about 1930 to 1949. From the estimated ages it would appear that most of the larger trees are at least 150 years old. Rather surprisingly,

the oldest tree in the sample is a 24-inch d.b.h. specimen of *Ulmus americana,* which would not be considered especially large, except that all the larger elms are dead.

The diversity of woody species in Sanford parallels the total diversity of its flora. Counting a few species no longer present, 81 spontaneous, native woody species occur there; 56 of these could be regarded as trees (or at least with the potential for attaining that growth form). This number amounts to about half the native trees of Michigan. Except for the conifers, of which only *Larix laricina* and *Thuja occidentalis* are spontaneous, the economically important tree species of Michigan are well represented.

HABITATS

The 1895 description of the forest provides a detailed view of many aspects of the woodland habitats. I shall therefore supplement this with a more generalized account. Two broadly defined situations can be recognized, the floodplain and the upland. The former has the richer flora, which probably reflects both the importance of floodwaters in seed dispersal and the greater diversity of environments near the river. The large number of species in the flora is of course directly related to the broad spectrum of habitats the Area affords. The following ten major habitat types are briefly described, with distinctive species indicated, proceeding insofar as possible from the wetter to the drier sites.

1. *River margin.* This habitat is a distinctive but not homogeneous environmental complex. In some places there is a nearly vertical bank up to four or five feet high; at other locations the bank is gradually sloping, and elsewhere are mud flats. *Acer saccharinum* is the most common tree on the bank. Among the more conspicuous herbaceous plants is *Saururus cernuus.* Many of the herbs, such as *Equisetum arvense, Rumex verticillatus,* and *Samolus parviflorus,* are more sporadic. Aquatics in the river include *Ceratophyllum demersum, Elodea nuttallii,* and *Lemna minor.*

2. *Intermittent lagoons.* A swampy area parallels the river along all but the west end of the woods. This is narrow to the west but becomes wider eastward. Characteristic woody plants are *Acer saccharinum, Carpinus caroliniana, Lindera benzoin, Quercus macrocarpa,* and elms (the latter mostly dead). Herbaceous species include *Arisaema dracontium, Boehmeria cylindrica, Chelone glabra, Dioscorea villosa, Eleocharis acicularis, Erythronium albidum, Iris virginica* var. *shrevei, Lobelia cardinalis,* and *Mimulus ringens.*

3. *River ridge.* A slightly higher ridge (natural levee) generally parallels the river and separates it from the lagoons. The ridge supports an abundant population of *Toxicodendron radicans* and a large assemblage of other species including various grasses, *Acer saccharum, A. nigrum, Allium tricoccum, Celtis occidentalis, Fagus grandifolia, Menispermum canadense, Sassafras albidum,* and *Zanthoxylum americanum.*

4. *Carlisle muck.* The muck patch near the southeast corner is of historical interest only, what with the part left after construction of Holmes Hall

being so thoroughly drained that it supports few of the species formerly there. A dense patch of *Laportea canadensis* is the principal survivor in the area that once had *Caltha palustris, Cornus stolonifera, Ilex verticillata, Larix laricina,* and *Toxicodendron vernix.* A small vernal pool in the extreme southeast corner of the woodlot contained a number of interesting species, but the widening of Hagadorn Road drained it.

5. *East-central lowland.* An extensive low but fairly well-drained area with several wet depressions occurs in the east-central portion of the woods. Common trees are *Acer saccharum, A. nigrum, Fraxinus americana,* and *Tilia americana.* A dense undergrowth of *Lindera benzoin* is frequently present. In the spring *Ranunculus septentrionalis* is conspicuous. Less abundant species include *Cardamine bulbosa, C. douglassii,* and *Cinna arundinacea.*

6. *Central north slope.* The slope north of the sugar house site is a springy area with a concentration of ferns including *Athyrium thelypterioides, Dryopteris goldiana,* and *D. spinulosa. Hydrastis canadensis* has also been found in this area, and in the late summer and fall *Collinsonia canadensis* is conspicuous.

7. *Northwest woods.* The lowland wooded portion of about two acres immediately north of Van Hoosen Hall has perhaps a greater number of native species than any other small area. Two large *Juglans cinerea* trees are present, a small tree of *Morus rubra,* abundant *Fagus grandifolia, Acer nigrum,* the only colony of *Hybanthus concolor,* a few *Dirca palustris,* abundant patches of *Asarum canadense,* and a number of plants of *Caulophyllum thalictroides* and *Actaea pachypoda.* Species of the edge and riverbank also contribute to the abundant flora of this locality.

8. *Southern upland.* The higher area to the south is the most homogeneous portion of the woods, but even it is hardly uniform. It is dominated by *Acer saccharum* with smaller amounts of *Fagus grandifolia, Tilia americana,* elms (mostly dead), *Fraxinus americana,* and *Quercus rubra* var. *borealis.* In late April the upland is abundantly covered with *Claytonia virginica. Dentaria laciniata, Erythronium americanum,* and *Hepatica acutiloba* are also common, while *Dicentra canadensis* and *Sanguinaria canadensis* occur in scattered colonies. *Dicentra cucullaria* and *Dirca palustris* are present but scarce. Slightly later flowering species include an abundance of *Trillium grandiflorum.* Common later in the spring and summer are *Geranium maculatum, Osmorhiza longistylis, Parthenocissus quinquefolia, Phlox divaricata, Viola canadensis,* and *V. pensylvanica.*

9. *Sugar house site.* The sugar house site is a more or less unique habitat. Although it is an opening not much more than 100 feet in diameter, a number of species occur there but hardly if at all elsewhere in the Area. These mostly successional species include *Aralia racemosa, Dipsacus laciniatus, Populus deltoides, P. grandidentata, P. tremuloides, Rhus typhina, Rubus occidentalis,* and *Scrophularia marilandica.*

10. *Edges.* Almost as many species are found around the edge of the Area as in its interior. Conspicuous among them are a large number of intro-

duced weeds. The west edge is especially rich in species both native and introduced. The Gramineae and Compositae are very well represented; one need only scan the checklist under these two families for an indication of their diversity. The west edge has been much disturbed by construction of Bogue Street Bridge, which required a large amount of fill. A number of species may have arrived by this means, while seeds of others may have been washed in by the river. The east edge is also an area of major disturbance from the widening of Hagadorn Road, likewise involving fill. It too has a rich weed flora, but the number of species is not so great as on the west side. The south edge of the woods also has its distinctive weed flora, differing considerably from the east and west edges. Major habitat disturbance has been less on the south side because the forest was simply chopped down to make room for dormitories and little if any fill was added. Some of the more characteristic species of the south edge are *Conyza canadensis, Helianthus decapetalus, Phytolacca americana,* and *Polygonum convolvulus.*

The permanency of many of the edge species is doubtful, since they will probably be replaced by other species, but many of them are hardy enough to persist somewhere around the woods. A few introduced species have even managed to gain roothold inside the woods, as for example *Arctium minus, Asparagus officinalis, Berberis thunbergii, Hemerocallis fulva, Hesperis matronalis, Lonicera tatarica, Lysimachia nummularia,* and *Myosotis scorpioides.* If such species become more abundant they will signal decline in the quality of Sanford as a natural area.

RARE SPECIES

Among the rare native species of south-central Michigan which now occur or once occurred in Sanford Natural Area, the following 30 are enumerated. Destruction of natural habitats through urbanization is the major reason these plants are becoming scarce. Some of the species listed are less common than others, and from the checklist still others could be added. Those cited below are at least illustrative of the richness and diversity in Sanford of relatively uncommon native woodland plants.

Aplectrum hyemale
Arisaema dracontium
Athyrium pycnocarpon
Carex molesta
Corallorhiza maculata
Cystopteris bulbifera
Dirca palustris
Dryopteris goldiana
Erythronium albidum
Euonymus atropurpureus
Festuca obtusa
Fraxinus quadrangulata
Gymnocladus dioica
Hybanthus concolor
Hydrastis canadensis
Juglans cinerea
Lilium michiganense
Liriodendron tulipifera
Matteucia struthiopteris
Morus rubra
Oryzopsis racemosa
Panax quinquefolius
Poa alsodes
P. nemoralis
P. palustris
Polymnia canadensis
Saururus cernuus
Stachys tenuifolia
Ulmus thomasii
Viburnum recognitum

SPECIES LOST FROM THE FLORA

The following nine species formerly occurred in Sanford Natural Area, but apparently are not there at the present time.

Caltha palustris
Cornus stolonifera
Euonymus atropurpureus
Gymnocladus dioica
Ilex verticillata
Larix laricina
Liriodendron tulipifera
Quercus velutina
Toxicodendron vernix

Five of these, *Caltha palustris, Cornus stolonifera, Ilex verticillata, Larix laricina,* and *Toxicodendron vernix,* grew in the swampy area where Holmes Hall was constructed. The only *Gymnocladus dioica* had already been cut down by 1896, and timber-cutting activities of the Forestry Department may have taken all *Liriodendron tulipifera.* The basis for the demise of the two other species is less certain. If early records of the flora were more complete it might be found that still other species have been lost, but the percentage probably would be low.

One of the reasons for the very large number of species now in Sanford is that many introduced species have been added to its flora, and most of the natives have persisted. We are currently faced with the problem of preventing further environmental deterioration which would increase the number of weeds and eliminate the precariously small populations of native species of limited ecological tolerance.

FUTURE PROSPECTS

In 1965 a group of biologists and campus planners met to discuss the biological values of Sanford Natural Area and to set up guidelines for its utilization. Among matters considered were relocation of walks and trails, fencing, signs and maps, disposal of dead timber, pesticides, a planting program, a formal dedication, and an inventory of the biota. Some recommendations of this group have already been implemented. One noteworthy guideline is that pesticides be completely banned on the grounds that such chemicals are incompatible with the concept of a natural area. The suggested planting program has been followed to some extent, although this also seems incompatible with the purposes of the Area. The present study provides an inventory of one aspect of the biota, but the other major taxonomic groups remain to be treated.

Maintaining Sanford as a *natural area* is the principal challenge facing those concerned with its future. It is not now entirely "natural" and can never be completely so. Yet it is an irreplaceable resource worth every effort and expense to preserve. An imminent danger is the foot traffic. More than 7,000 students live in the neighboring dormitories, not to mention all those in the mass of apartments on the north side of the river. In 1957 President John A. Hannah noted (letter to Dr. W. B. Drew, Chairman, Department of Botany and Plant Pathology) that "in the not too distant future . . . it will be so tramped over as to make it fail completely to serve your students as a typical wood lot situation." This grim prediction may soon be fulfilled, for even

though ample trails are provided new ones are constantly being formed. Dr. G. W. Parmelee (letter to *State News*) describes this process as pounding "the spongy forest floor with its wealth of delicate forest herbs and tree seedlings into barren 'earth-crete'."

The concentration of people has already made it impossible for certain studies to be effectively carried out in the Area. For example, disturbance of stones and fallen trees makes it unsatisfactory for courses in cold-blooded vertebrates. Experimental ecological studies are impossible because of disturbance and vandalism. According to Dr. G. J. Wallace it is no longer very good for ornithological field trips because such species as grackles and starlings have replaced nesting Louisiana water thrushes and oven birds. One indication of wanton disregard for the Area is the numerous beer bottles, cans, and food wrappers scattered about.

Several natural factors, however, contribute to the preservation of the woodlot. During much of the winter the soil is frozen, thus helping prevent soil compaction. In the spring, when the wild flowers are most attractive, many of the days are cold, windy, or wet, discouraging the casual wanderer. By late spring mosquitos are out in full force and they remain a potent defensive army for much of the summer. In spring, summer, and fall there is enough poison ivy near the river to limit trampling by the less naive, and during the summer wood-nettle stands guard at many moister sites.

A very substantial fence, with an entrance only on the west side, would seem the best solution for reducing unnecessary traffic. The present low fence with six gates (four on the south side) is entirely ineffective. Some of the new trails have actually developed from the gate locations. On the north side the river is an excellent barrier, but frozen it becomes a thoroughfare between the campus and the apartments and Grand River Avenue shopping district. In 1895 the College invested in a fence on private property along the north side of the river to prevent cattle from entering the woodlot across the frozen river. Such a fence for people now seems impossible, but one along the south and east boundaries would at least discourage use of the woodlot as a short-cut and sidewalk.

It is also urgent that there be a vigorous educational program for the public, especially the academic community, concerning the values of Sanford Natural Area and the reasons it is seriously endangered. A fence would help in the educational process, but also needed are frequent press reports, more intensive supervision of the Area, adequate signs, and an attractive descriptive brochure. If these measures fail to halt deterioration, closing the woodlot to all unauthorized persons could be justified on grounds of its formal instructional and research values.

Whatever the future holds for Sanford Natural Area, it will be instructive as to the possibilities for coexistence of nature's handiwork and thousands of university students. It has already served the community well for over a century. If proper protective measures are taken, I believe it can continue to benefit future generations of students and faculty, illustrating the biological principles of a natural area.

SUMMARY

Sanford Natural Area is a 35-acre woodlot on the Michigan State University campus which has been used for teaching and research for over a century. For 65 years it was managed as a demonstration of good woodlot practices for continuous and lasting crops; maple syrup production was a major research subject. In 1959 administrative responsibility for the Area was shifted from the Forestry Department to Campus Park and Planning. With the change in administration came a redefinition of purpose: It now serves to illustrate the biological principles of a natural area. Nearly 1500 students in 21 University courses in eight departments use it each year as an outdoor laboratory. It is most conveniently located for teaching of all wooded areas on campus, and is perhaps the botanically most varied of all woodlots in the vicinity of East Lansing. The large flora of 358 species of vascular plants reflects the diversity of habitats in the Area. Ten major habitat types are recognized. The dominant tree is *Acer saccharum,* but nine other tree species are important components of the forest. Among the 81 native woody species present 56 are trees. The larger trees are more than 30 inches d.b.h., over 100 feet high, and many of them are probably more than 200 years old. At least 30 species in the flora are rare in central Michigan. Nine species formerly present have been lost, in large part because a major habitat was destroyed by building construction. Expansion of the University in the past 15 years has resulted in 20 acres formerly occupied by the woodlot being utilized for four large dormitories. Increased foot traffic from more than 7,000 students in these and other nearby residents units and from the rest of the enlarging community threatens to obliterate many natural features of the Area. Adequate fencing and a vigorous educational program appear to offer the most effective means for preserving this endangered natural environment.

ACKNOWLEDGMENTS

Students of Michigan State University have made this study possible, and it is to them that I am particularly indebted. Their role is somewhat evident from the specimens cited in the checklist to be published as part II. Those who have made major contributions include Dr. Norton G. Miller of Harvard University, Dr. William T. Gillis of Fairchild Tropical Garden, Jerold L. Grashoff of the University of Texas, Larry E. Morse, Joan M. Hubbard, Martin A. Bordner, Richard R. Nelson, Thomas J. Popma, and Basil G. Stergios. Miss Darlene M. Valasek has been most helpful in attending to many details in the final stages of the project. A fine series of collections was made by Dr. L. C. Anderson of Kansas State University when he was on our faculty in 1962-63. Drs. G. W. Parmelee and G. Schneider have loaned records of the Division of Campus Park and Planning and the Department of Forestry, respectively, and have contributed otherwise to the study, especially by critically reading the manuscript. Dr. E. P. Whiteside examined the soils in the field, revised the nomenclature on the original soils map of the Area, and provided other information on the soils. Dr. S. N. Stephenson has provided advice on ecological procedures and helped in the identification of the Gramineae. Dr. E. G. Voss identified several species, especially *Carex,* and Dr. W. H. Wagner, Jr., checked the fern identifications. The cost of additional pages and other expenses of the study have been borne by the Department of Botany and Plant Pathology.

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MOSSES NEW TO THE FLORA OF MICHIGAN[1]

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As a result of continuing field and herbarium studies, seven species of mosses can be recorded as new to the known flora of Michigan, as follows:

Sphagnum tenerum Sull. & Lesq. ex Sull. Cheboygan Co.: In a cedar swamp, in the open, ¾ mile northeast of Pine Grove State Forest Campground, T33N, R1W, sect. 16, *Richard C. Harris 788* (MICH, MSC). Chippewa Co.: In a spruce-jack pine area, Dick State Forest Campground, T44N, R5W, sect. 2, *Harris 1153* (MSC), Clare Co.: In a *Thuja* swamp west of Farwell, T17N, R5W, sect. 28, *Harris 992B* (MICH, MSC); in a *Thuja* swamp, Silver Lake, T18N, R5W, sect. 30, *Harris 1011* (MICH, MSC). Eaton Co.: In a *Vaccinium* bog, Kikendall farm, near Dimondale, T1N, R3W, *Harris 893* (MSC). Ingham Co.: In an old tamarack-leatherleaf bog, Holt Bog, T3N, R2W, sect. 21, *Harris 874* (MICH, MSC), 882 (MSC). Mackinac Co.: On a log, near a *Thuja,* Lake Huron shore west of Hessel, T42N, R2W, sect. 22, *Harris 1095*

[1]Contribution from the Herbarium of the University of Michigan and also from the University of Michigan Biological Station. Grateful acknowledgment is made for the National Science Foundation for research funds provided under grant GB6095.

(MSC); Prentiss Bay, *J. H. Ehlers,* July 30, 1920 (MSC). Otsego Co.: In a *Thuja*-spruce-alder swamp on Whitehouse Road, 0.7 miles north of Lake Shore Drive, *H. Crum,* Aug. 7, 1969 (MICH). Roscommon Co.: At edge of muck, without locality, *J. Cantlon & W. Gillis,* July 1956 (MSC). – *S. tenerum* is quite variable in its overall appearance but most commonly resembles *S. capillaceum* (Weiss) Schrank, to which it is obviously related. It differs from that species essentially in the "hemi-isophyllous" nature of the stem leaves, which approach the branch leaves to some extent in shape (being somewhat pointed and concave at the tip and not very strongly bordered at the base) and in structure (having hyaline cells fibrillose nearly throughout the leaf and porose on both surfaces). The stem leaves of *S. capillaceum* also show some degree of hemi-isophylly, but the fibrils are not so well or so extensively developed, and the pores, if present at all, are few, large, rounded, and restricted to the inner surface. In *S. tenerum,* by contrast, there are three to five large, rounded pores on the inner surface of each cell and more numerous elliptic pores along the commissures on the other surface.

The species occurs in bog forests and also in more open situations, such as blueberry or tamarack-leatherleaf bogs from Newfoundland to Florida and less commonly inland in scattered localities in Quebec, Ontario, Michigan, Missouri, and, very disjunctively, in British Columbia.

Fissidens subbasilaris Hedw. Washtenaw Co.: On an old, rotten tree trunk, woods near Ypsilanti, *H. T. Darlington,* June 9, 1928 (MSC, MICH). – This species is included in Darlington's *Mosses of Michigan,* but insofar as I have been able to ascertain, on the basis of misidentifications. It is easily recognized with a microscope or even with a lens because the upper portion of the costa is obscured by a covering layer of short, green cells. Though scattered and rare in the North, it is a widely distributed species throughout eastern North America from Maine and southern Ontario west to Kansas and south to northeastern Mexico and Florida. It grows on the bark of trees and sometimes on rotten wood or rock.

Grimmia plagiopodia Hedw. Cheboygan Co.: On a calcareous sandstone boulder in the railroad right-of-way, in the complete shade of a young spruce (and covered by its lower boughs), Mill Creek, ca. 3 miles southeast of Mackinaw City on U. S. Highway 23, *H. Crum,* June 25, 1969 (MICH, UMBS). – A rare and interesting species in eastern North America, *G. plagiopodia* greatly resembles the ubiquitous *G. apocarpa* because of its brownish leaves ending in hyaline hair-points, but it is actually very distinctive because of its wide-mouthed capsules bulging on one side and thus causing the short, curved or even curled setae to seem excentric in attachment. The presence of a peristome is an important distinction between *G. plagiopodia* and *G. anodon* BSG. The plants are typically found on sandstone but sometimes occur on limestone or concrete. The species is distributed in Europe, the Caucasus, and central Asia, Alaska to California and New Mexico, and in a few eastern localities from Ontario and the Dakotas south to Wisconsin, Ohio, and Maryland.

Philonotis capillaris Lindb ex C. J. Hartm. Chippewa Co.: On soil of a roadside ditch bank, about 3 miles northwest of Homestead, Sugar Island, *H. Crum,* July 1969 (MICH). – A species of circumpolar distribution, reputedly widespread in the East from Maine to Virginia and also in the West from Alaska to Arizona and New Mexico. Reports in the literature are to be viewed with skepticism, however, as this and other species of *Philonotis* are more often misidentified than not. From specimens readily available to me, I can confirm the American distribution as including Arkansas, Michigan, New York, British Columbia, Washington, and California. I have also seen material from Germany.

Orthotrichum alpestre Hornsch. ex BSG. Keweenaw Co.: Mt. Bohemia, *A. J. Sharp,* Sept. 1, 1937 (TENN). – This species, common on the calcareous rocks so prevalent in the western mountains from Yukon to Arizona, is not otherwise known from eastern North America. The substrate is not given for the Michigan collection, but it was probably some acid type of rock. The species also occurs in northern and central portions of Eurasia. I am indebted to Dale H. Vitt for calling my attention to this significant range extension, which we have both confirmed.

Brachythecium digastrum C. M. & Kindb. ex Mac. & Kindb. Ingham Co.: Woodlot 17, Second College Woods, East Lansing, *H. T. Darlington,* May 1, 1934 (MSC, MICH). – This species was reported from Clinton and Gratiot Counties in Darlington's *Mosses of Michigan,* but I have not seen any correctly named material to validate the records. *Brachythecium digastrum* is somewhat similar to the common *B. oxycladon* (Brid.) Jaeg. & Sauerb., as evidenced by a similar areolation at the basal angles of the leaves, but the stem leaves are rather broadly decurrent, especially in forms with widely spaced leaves; the branches are more terete-foliate; and the branch leaves are tapered to short, bluntly acute, serrate points, with apical cells noticeably shorter than the median and the costa somewhat serrulate at back near the tip. I have seen specimens from a broad range in eastern North America (Arkansas, Michigan, North Carolina, Ontario, Quebec, and Virginia). The species was described on the basis of collections from Ontario and New Brunswick.

Isopterygium subfalcatum (Aust.) Jaeg. & Sauerb. Eaton Co.: On moist earth in open woods, west of Fitzgerald Park, south shore of Grand River just northwest of Grand Ledge, *H. T. Darlington,* May 2, 1951 (CAN). Chippewa Co.: On rock in woods, Lower Falls of the Tahquamenon River, *R. R. Ireland 4346* (CAN). – A rare species growing on moist siliceous cliffs or sometimes on the peaty soil of banks, *I. subfalcatum* occurs disjunctively over a broad range from Maine to Michigan and south to Arkansas and North Carolina. *Taxiphyllum howellianum* Crum & Anders., described not too long ago from North Carolina collections, belongs in the synonymy of this species. I am grateful to Robert R. Ireland for supplying the determinations for both specimens cited here, as well as for clarifying the nomenclature.

Review

HOW TO KNOW THE AQUATIC PLANTS. By G. W. Prescott. Wm. C. Brown Co., Dubuque. 1969. 171 pp. $2.50 (spiral); $3.25 (cloth).

The chief value of this book is its particular scope. The geographic area covered is the entire U. S. and the definition of aquatic is broad (unlike Muenscher's manual for the U. S.), even broader than in Fassett's northeastern manual, for some marine angiosperms and bog plants are included. The format is that of the familiar Pictured Key Nature Series, but the key is only to the genera—about 165 of them—although some species are mentioned. Beginners who for some reason want to know only the generic name of an aquatic angiosperm or conspicuous cryptogam and who have a good deal of patience and intuition with which to approach the rather casual key of 301 couplets may find the volume helpful.

The key is commendable in including many genera at more than one place, so that variability of either Nature or interpretation need not lead to error in identification. But such error is still likely to result from frequent failure of the key to use the most obvious distinguishing characters or to contrast clearly the characters used. There is a great excess of the utterly uninformative "Plant otherwise"; after sailing through five consecutive leads like this and failing to arrive at *Elatine,* I had to conclude that this genus (strictly submersed in Michigan) was to be reached only by lead 62b in this couplet, most of which does not contrast, leaving one helpless with a rooted submersed plant:

62a. Plants submersed and essentially rooted to the bottom, sometimes at 8 M (often becoming free-floating); with or without floating leaves.

62b. Plants rooted on shore or in shallow water, emergent, sprawling or growing erect at margins of aquatic habitats.

Couplet 242 will not distinguish *Eleocharis* (which *has* a sheath at the base of each slender stem) from *Scirpus.* The flowers of *Ruppia* are *not* "in a simple umbel" nor are the leaves "mostly basal" (except perhaps when stranded); this normally submersed species with extremely long alternate leaves is said to grow "on saline or alkaline shores." *Littorella,* in contrast, is said to grow "submersed," although the figure shows it flowering, a condition occurring only on shores. I cannot imagine anyone finding *Littorella* "difficult to differentiate" from *Ruppia,* the former having basal rosettes of short leaves—which, in Michigan at least, are not "dark green" or "with a broad sheathing base," but a distinctive light green, terete, and no broader at base than the middle. The whole group of small rosette-formers of our softwater lakes (e.g., *Littorella, Eriocaulon, Lobelia dortmanna, Isoëtes, Subularia*) fares very badly in this key, which makes these distinctive plants excessively difficult to compare.

The main discussion of *Potamogeton,* with figures of several species, follows couplets 58 and 59 which both call for opposite leaves. At couplet 284, under alternate leaves, there is merely a reference back to this point. Couplet 116 distinguishes *Rorippa* ("Flowers greenish white") from *Neobeckia, Cardamine,* and *Nasturtium* ("Flowers white, yellow or lavender"). In fact, the latter three are not yellow-flowered, while *Rorippa* always is. In referring to *R. aquatica* "with whitish flowers," the author apparently is unaware that this name is synomymous with his *Neobeckia (Armoracia) aquatica,* intended to run under the alternate lead! Submersed plants of *Megalodonta* "may be confused with some species of *Ranunculus* or *Neobeckia*"—and indeed they may when one fails to mention that the latter two differ most obviously in having alternate leaves.

The glossary combined with the index is frequently weak as well as incomplete. Alternate is an arrangement, not "leaves . . ."; phyllodia is a plural word; "cilliate" is not the correct spelling. The Introduction concludes with a list of 15 divisions of the plant kingdom (9 of which are algae), immediately after which is the statement: "When all the aquatic plant species are placed in review it is noteworthy that a majority are in the Monocotyledonae of the seed plants." That the algologist author could let such an astonishing assertion slip by is perhaps indicative of the care with which this volume seems to have been written.

—E. G. V.

Program Notes

Michigan Botanical Club and chapter members will be receiving further information about these major events:

April 13: Huron Valley Chapter, Annual Meeting at the University of Michigan Botanical Gardens. Dr. Rogers McVaugh will talk on "Botanical Activities of the Geological Survey of Michigan, 1837-1840," relating the story of the early collections made under the supervision of Douglass Houghton.

May 29-31: Michigan Botanical Club, Annual Spring Campout, at the University of Michigan Biological Station on Douglas Lake. A full program of field trips is expected, including all-day ones to the Upper Peninsula limestone country for spring flora and rare ferns, led by W. H. Wagner; to Trail's End Bay and Wilderness State Park, led by Ed Voss; and to Bois Blanc Island, led by Morgan Poole.

June 28: Southeastern Chapter, Annual Meeting, at the Drayton Plains Nature Center.

September 25-27: Southeastern Chapter, Fall Campout, at Yankee Springs.

Editorial Notes

Errata in Vol. 9, No. 1 (January 1970):
p. 16, line 4 from bottom, insert "200 pp."
line 8 from bottom, for "3" read "2"
p. 61, line 17 from bottom, insert reference: "Brittonia 21: 196-200"

Authors of articles in recent issues who wish to have manuscripts and/or art work returned should advise the editor immediately, before another "housecleaning" of his files.

The January number (Vol. 9, No. 1) was mailed January 22, 1970.

Publications of Interest

From time to time we call attention, under this heading, to new publications which might be of particular interest to some of our readers but which, because of less explicit geographic or botanical orientation, do not qualify for regular review or inclusion in the listings of new literature relating to Michigan botany. All annotations are by the Editor unless ascribed to another.

A SHORT HISTORY OF BOTANY IN THE UNITED STATES. Edited by Joseph Ewan. Hafner Publishing Co., New York, 1969. 174 pp. $7.50. Distributed to all registrants at the XI International Botanical Congress in Seattle last August, this volume offers a general survey of American botanical history, with chapters by 13 authors on specific areas of botany. One of the most interesting contributions is Ewan's "Calendar of Events," 300 B.C. to 1968, wherein one may learn a fascinating series of historical tidbits and highlights. Ewan also contributed a 23-page chapter on "Early History" and a 9-page one on "Plant Geography."

SPRING FLORA OF MINNESOTA Including Common Cultivated Plants. By Thomas Morley. University of Minnesota Press, Minneapolis, 1969. 283 pp. $7.75. This is a hardcover edition of the work published in 1966 by the Department of Botany and enthusiastically noted in this journal in January, 1968. The same type has been used, except for various corrections and minor revisions. One useful innovation is marking with an asterisk the names of those genera for which all species native or naturalized in Minnesota are included; thus, one immediately knows whether a genus includes additional species which bloom after June 7. Perhaps the most conspicuous change is the price, which has more than doubled, making this a very expensive binding!

MICHIGAN SCIENCE IN ACTION is the title of a new series of publications which relates research developments at the Michigan Agricultural Experiment Station. Nine numbers have been issued during the past year, and copies may be obtained by writing to the MSU Bulletin Office, Box 231, East Lansing, Michigan 48823: 1. Focus on Pests and Pesticides, 2. Sod and Turf–Michigan's $350 Million Carpet, 3. Focus on Food Science, 4. Focus on the Family, 5. Reshaping the Soil, 6. Focus on Beef Cattle, 7. Bedding Plants: Michigan's Blooming Industry, 8. Scientific Achievements: 1888-1969, 9. Focus on Dairy Nutrition.

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(On the cover: A white waterlily, Nymphaea,
blooming at Cusino Lake, Schoolcraft County, Michigan.
Photograph by Gary R. Williams, August 15, 1969.
See p. 80.)

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THE

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May, 1970

THE MICHIGAN BOTANIST—Published by the Michigan Botanical Club four times per year: January, March, May, and October. Second-class postage paid at Ann Arbor, Michigan.

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Subscriptions (from those not members of the Michigan Botanical Club) and all orders for back issues should be addressed to the business and circulation manager, who will assume that subscriptions received prior to the last number of a volume are intended to begin with the first number of that volume unless specified to the contrary.

Articles and notes dealing with any phase of botany relating to the Upper Great Lakes Region may be sent to the editor in chief. The attention of authors preparing manuscripts is called to "Information for Authors" (Vol. 9, p. 62; copies available from the editor).

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Membership in the Michigan Botanical Club is open to anyone interested in its aims: conservation of all native plants; education of the public to appreciate and preserve plant life; sponsorship of research and publication on the plant life of the State; sponsorship of legislation to promote the preservation of Michigan native flora and to establish suitable sanctuaries and natural areas; and cooperation in programs concerned with the wise use and conservation of all natural resources and scenic features.

Dues are modest, but vary slightly among the chapters and with different classes of membership. Persons desiring to become state members (not affiliated with a local chapter) may send $3.00 dues to the Membership Chairman listed below. In all cases, dues include subscription to THE MICHIGAN BOTANIST. (Persons and institutions desiring to subscribe without becoming members should deal with the business and circulation manager as stated at the top of this page.)

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A BOTANICAL INVENTORY OF SANFORD NATURAL AREA. II. CHECKLIST OF VASCULAR PLANTS

John H. Beaman
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A general account of the environment of Sanford Natural Area was published previously (Beaman, 1970). The following checklist includes vascular plants which now occur in the woodlot and a few others which are no longer present. Only spontaneous plants are included, with the exception of three species which have persisted from planting in 1896. Collections cited are deposited in the Beal-Darlington Herbarium of Michigan State University. A large number of specimens collected in the 1890's labeled "College Woods" are most likely from Sanford, but are not cited because of the possibility that they are from a different woodlot. All collections cited have been obtained within the past 30 years, most since 1960.

Flowering dates of the angiosperms are based on specimens in the Beal-Darlington Herbarium from the southern half of the Lower Peninsula of Michigan. Many species, especially those of the spring flora, are evident for a very short period. The dates indicated should help suggest to the student what species to expect at a particular time of year. Phenological records also have other uses as in studies of productivity and ecosystem analysis. Optimally they would include aspects of plant development throughout the year, but a commonly recorded feature is date of first flowering (e.g. Taylor, 1969). Such data are not available for the species of Sanford Natural Area nor for most plants in Michigan.

The systematic arrangement is as follows: Horsetail, fern, and gymnosperm higher taxa, Cronquist et al. (1966); fern and gymnosperm families, Melchior & Werdermann (1954); angiosperms, Cronquist (1968); genera and species of each family, alphabetical.

The checklist includes 90 families, 230 genera, and 355[1] species. Of this number, 279 species are native, 73 introduced, and three planted. It is noteworthy that 60% of the 151 vascular plant families in Michigan occur in Sanford Natural Area. Well over 10% of the species of vascular plants in the Michigan flora are present. The largest families are the Gramineae with 21 genera and 33 species and the Compositae with 19 genera and 33 species. The largest genus is *Carex* with 16 species. Eight other genera, *Quercus, Viola, Salix, Cornus, Acer, Viburnum, Solidago,* and *Poa,* each have five or more species.

---

[1]In part I the number of species was reported as 358, but revised determinations reduce the total by three.

EQUISETOPHYTA (Horsetails)

EQUISETACEAE (Horsetail Family)

Equisetum arvense L. Horsetail. *Lauff 9.* Along the river.

E. hyemale L. Scouring rush. *Grashoff 307.* On riverbank at NW corner.

POLYPODIOPHYTA (Ferns)

OPHIOGLOSSACEAE (Adder's-tongue Family)

Botrychium virginianum (L.) Sw. Rattlesnake fern. *Humphrey 204; Throop 6.* Scattered NE of sugar house site. Rare.

OSMUNDACEAE (Royal Fern Family)

Osmunda regalis L. Royal fern. *Nelson 153.* Middle portion near river.

POLYPODIACEAE (Polypody Family)

Adiantum pedatum L. Maidenhair fern. *Humphrey 201; Nelson 188.* Scattered NW of sugar house site in moist areas.

Athyrium asplenioides (Michx.) Desv. Lady fern. *Nelson 152.* Middle portion near river.

A. pycnocarpon (Spreng.) Tidest. Narrow-leaved spleenwort. *Ciarkowski 56; Miller 4525.* E-central part in rich moist soil.

A. thelypterioides (Michx.) Desv. Silvery spleenwort. *Nelson 199.* In wet soil in central part.

Cystopteris bulbifera (L.) Bernh. Bulblet fern. *Hymphrey 203; Nelson 107.* On riverbank in NW section.

C. fragilis (L.) Bernh. Fragile fern. *Bordner 171.* S bank of river.

Dryopteris goldiana (Hook.) Gray. Goldie's fern. *Humphrey 205; Miller 4524.* Central and E part in moist soil.

D. spinulosa (O. F. Muell.) Watt. Spinulose shield-fern. *Bordner 174; Nelson 163.* SE and middle part. *Bordner 174* appears to be of hybrid origin.

Matteuccia struthiopteris (L.) Todaro. Ostrich fern. *Nelson 154, 199, 251.* Middle portion near river.

Onoclea sensibilis L. Sensitive fern. *Marshall 284; Nelson 200, 202.* Central and E part in wet soil.

Polystichum acrostichoides (Michx.) Schott. Christmas fern. *Humphrey 200; Nelson 160.* N-central area.

Thelypteris hexagonoptera (Michx.) Weatherby. Broad beech-fern. *Nelson 103.* near middle of woods. Rare.

T. palustris var. *pubescens* (Lawson) Fern. Marsh fern. *Valasek 439.* By intermittent lagoon in N-central part.

PINOPHYTA (Gymnosperms)

PINACEAE (Pine Family)

Larix laricina (DuRoi) K. Koch. Tamarack. Noted in 1895 in marshy area on SE edge, the present site of Holmes Hall.

Tsuga canadensis (Endl.) Carr. Hemlock. *Nelson 109.* Planted specimens in NW quarter on high ground above riverbank.

CUPRESSACEAE (Cypress Family)

Thuja occidentalis L. White cedar or arbor vitae. *Nelson 304.* NW portion on riverbank.

MAGNOLIOPHYTA (Angiosperms)

MAGNOLIATAE (Dicotyledons)

MAGNOLIIDAE

MAGNOLIACEAE (Magnolia Family)

Liriodendron tulipifera L. Tulip-poplar. Management records indicate that this species was once present, but specimens have not been located. Flowering in June.

ANNONACEAE (Custard-apple Family)

Asimina triloba (L.) Dunal. Pawpaw. *Grashoff 298.* Known only from one small tree on the N bank of the river, which succumbed to apartment construction in the fall of 1968. Flowering in May.

LAURACEAE (Laurel Family)

Lindera benzoin (L.) Blume. Spicebush. *Hubbard 7; Marshall* in 1949. Common in wet areas. Flowering in April.

Sassafras albidum (Nutt.) Nees. Sassafras. *Grashoff 320.* Infrequent in N-central portion near the river. Flowering in May.

SAURURACEAE (Lizard's-tail Family)

Saururus cernuus L. Lizard's-tail. *Anderson 2162; Lauff* in 1950. Abundant on river margin. Flowering June - August.

ARISTOLOCHIACEAE (Birthwort Family)

Asarum canadense L. Wild ginger. *Anderson 2253; Ellsworth* in 1949; *Hubbard 25.* Patches scattered in low areas. Flowering April - June.

CERATOPHYLLACEAE (Hornwort Family)

Ceratophyllum demersum L. Hornwort. *Nelson 299.* Submerged aquatic collected in the river only near Bogue Street bridge, but probably more abundant. Flowering July - August.

RANUNCULACEAE (Crowfoot Family)

Actaea pachypoda Ell. White baneberry. *Halicki* in 1957; *Hubbard 44.* Scattered through the woods. Flowering May - June.

Anemone quinquefolia var. *interior* Fern. Wood anemone. *Anderson 2257; Grashoff 283; Hubbard 17.* Uncommon. Flowering April - May.

Caltha palustris L. Marsh-marigold. *Anderson 2230.* The species was once abundant in the marshy area on the SE side. It was exterminated by construction of Holmes Hall. Flowering April - June.

Hepatica acutiloba DC. Liverleaf. *Anderson 2217; Hubbard 10; Marshall 1517.* Frequent throughout much of the woods. Flowering April - May.

Hydrastis canadensis L. Golden-seal. *Grashoff 300.* In central part, rare. Flowering in May.

Isopyrum biternatum (Raf.) T. & G. False rue-anemone. *Hubbard 35; Stergios 17.* Infrequent. Flowering April - May.

Ranunculus abortivus L. Small-flowered crowfoot. *Grashoff 279; Hubbard 34.* Occasional in disturbed situations. Flowering May - June.

R. pensylvanicus L.f. Bristly crowfoot. *Grashoff 31.* On riverbank, apparently rare. Flowering in July.

R. recurvatus Poir. *Grashoff 315.* Apparently rare. Flowering May - June.

R. septentrionalis Poir. Swamp buttercup. *Hubbard 24.* Common by vernal pools in E-central portion. Flowering April - June.

Thalictrum dasycarpum Fisch. & Lall. Purple meadow-rue. *Nelson 108.* On riverbank; rare. Flowering June - July.

T. dioicum L. Early meadow-rue. *Grashoff 278; Stergios 8, 14.* Scattered in low areas. Flowering April - May.

BERBERIDACEAE (Barberry Family)

Berberis thunbergii DC. Japanese barberry. *Grashoff 296; Stergios 7.* Introduced; scattered through the woods. Flowering April - May.

Caulophyllum thalictroides (L.) Michx. Blue cohosh. *Anderson 2256; Hubbard 27.* Common. Flowering April - May. (See cover photo.)

Podophyllum peltatum L. May-apple. *Hubbard 45.* Several scattered patches. Flowering in May.

MENISPERMACEAE (Moonseed Family)

Menispermum canadense L. Moonseed. *Grashoff 311.* Common near the river. Flowering June - July.

PAPAVERACEAE (Poppy Family)

Sanguinaria canadensis L. Bloodroot. *Gillis 2886; Hubbard 16.* Scattered through the woods. Flowering April - May.

FUMARIACEAE (Fumatory Family)

Dicentra canadensis (Goldie) Walp. Squirrel-corn. *Anderson 2239; Hubbard 30; Marshall 293.* Frequent in patches. Flowering April - May.

D. cucullaria (L.) Bernh. Dutchman's breeches. *Anderson 2240; Grashoff 281; Stergios 25.* Infrequent in a few patches. Flowering April - May.

HAMAMELIDAE

PLATANACEAE (Plane-tree Family)

Platanus occidentalis L. Sycamore. *Valasek 430.* Floodplain in N-central part. Flowering in May.

HAMAMELIDACEAE (Witch-hazel Family)

Hamamelis virginiana L. Witch-hazel. *Anderson 2286; Hubbard 4; Popma 332.* Frequent near the river. Flowering September - October.

ULMACEAE (Elm Family)

Celtis occidentalis L. Hackberry. *Nelson 161.* Rare tree near the river. Flowering in May.

Ulmus americana L. American elm. *Horning 16.* Formerly one of the dominants, but most large trees killed by Dutch elm disease during the 1960's. Flowering in April.

U. rubra Muhl. Slippery or red elm. *Nelson 309.* Near the river. Flowering April - May.

U. thomasii Sarg. Rock elm. Apparently frequent in 1895, but only one tree (13 inches d.b.h.) on the W side just east of the ravine has been located recently. A specimen has not yet been prepared. Flowering April - May.

MORACEAE (Mulberry Family)

Morus alba L. White mulberry. *Nelson 102.* Introduced. Infrequent. Flowering in May.

M. rubra L. Red mulberry. *Valasek 427.* NW and N-central portion, rare. Flowering May - June.

URTICACEAE (Nettle Family)

Boehmeria cylindrica (L.) Sw. Bog-hemp. *Anderson 2165; Nelson 215, 252, 301.* In low, wet areas near the river. Flowering June - August.

Laportea canadensis (L.) Wedd. Wood-nettle. *Anderson 2164; Nelson 165.* Forming dense colonies in moist areas. Flowering June - August.

Parietaria pensylvanica Muhl. Pellitory. *Nelson 149.* Abundant in patches in disturbed areas mostly near trails. Flowering June - July.

Pilea pumila (L.) Gray. Clearweed. *Anderson 2166; Nelson 270.* Abundant in very wet soil. Flowering August - September.

Urtica gracilis Ait. Nettle. *Nelson 237, 327.* In open, wet, disturbed situations. Flowering July - August.

JUGLANDACEAE (Walnut Family)

Carya cordiformis (Wang.) K. Koch. Bitternut hickory. *Horning* in 1960; *Nelson 164.* Scattered through the woods. Flowering in May.

C. ovata (Mill.) K. Koch. Shagbark hickory. *Nelson 201.* Rare; in central portion. Flowering in May.

Juglans cinerea L. Butternut. *Nelson 116.* Near river in NW section. Flowering in May.

J. nigra L. Black walnut. *Valasek 446.* One large tree between Bogue Street and Van Hoosen parking lot. Flowering in May.

FAGACEAE (Beech Family)

Castanea dentata (Marsh.) Borkh. Chestnut. Planted in 1896; the last tree was apparently removed in the construction of Van Hoosen Hall. Flowering June - July.

Fagus grandifolia Ehrh. Beech. *Anderson 2278; Horning 10; Hubbard 6.* One of the most important dominant trees. Flowering in May.

Quercus alba L. White oak. *Horning 34.* Scattered throughout. Flowering in May.

Q. bicolor Willd. Swamp white oak. *Morse 7004.* Rare; on floodplain in N-central part. Flowering in May.

Q. macrocarpa Michx. Mossy-cup or bur oak. *Nelson 203, 308.* On the floodplain. Flowering in May.

Q. muehlenbergii Engelm. Chestnut oak. *Nelson 191.* Rare; in NW part. Flowering May - June.

Q. rubra var. *borealis* (Michx. f.) Farw. Northern red oak. *Nelson 119.* Frequent. Flowering in May.

Q. velutina Lam. Black oak. Noted in 1895 but not located in recent years. Flowering in May.

BETULACEAE (Birch Family)

Carpinus caroliniana Walt. Ironwood or blue-beech. *Anderson 2158; 2259.* Frequent near the river. Flowering April - May.

Ostrya virginiana (Mill.) K. Koch. Ironwood or hop hornbeam. *Horning* in 1960; *Hubbard 8.* Scattered through the woods. Flowering April - May.

CARYOPHYLLIDAE

PHYTOLACCACEAE (Pokeweed Family)

Phytolacca americana L. Pokeweed. *Nelson 213.* Frequent weed in open area on S. edge. Flowering June - October.

CARYOPHYLLACEAE (Pink Family)

Lychnis alba Mill. White cockle. *Hubbard 60.* Introduced weed in open areas. Flowering May - October.

Stellaria media (L.) Cyrill. Common chickweed. *Nelson 196.* Introduced weed in open, disturbed areas. Flowering May - July.

PORTULACACEAE (Purslane Family)

Claytonia virginica L. Spring beauty. *Hubbard 12; Shipman 6.* Abundant throughout upland portion. Flowering March - May.

CHENOPODIACEAE (Goosefoot Family)

Chenopodium album L. Pigweed or lamb's-quarters. *Nelson 226.* Introduced weed in open area at edge. Flowering July - September.

AMARANTHACEAE (Amaranth Family)

Amaranthus tuberculatus (Moq.) J. D. Sauer. Water-hemp. *Nelson 295.* In open sandy soil on riverbank; rare. Flowering July - September.

POLYGONACEAE (Buckwheat Family)

Polygonum aviculare L. Knotweed. *Nelson 144.* Introduced; infrequent weed on open edges. Flowering July - October.

P. convolvulus L. Black bindweed. *Nelson 318.* Introduced weed along open edge. Flowering July - August.

P. lapathifolium L. Smartweed. *Nelson 262, 298.* Infrequent in open situations near the river. Flowering July - August.

P. virginianum L. Jumpseed. *Grashoff 16.* Common throughout the woods. Flowering July - August.

Rumex crispus L. Yellow dock. *Grashoff 338A; Nelson 175.* Introduced weed in open area at edge. Flowering in June.

R. verticillatus L. Water dock. *Valasek 434.* N-central part along river. Flowering June - August.

DILLENIIDAE

GUTTIFERAE (St. John's-wort Family)

Hypericum perforatum L. St. John's-wort. *Nelson 183.* Introduced; infrequent weed at edge. Flowering June - July.

TILIACEAE (Linden Family)

Tilia americana L. Linden or basswood. *Anderson 2279; Horning 5; Hubbard 2.* A common large tree. Flowering May - June.

VIOLACEAE (Violet Family)

Hybanthus concolor (Forster) Spreng. Green violet. *Gilly & Parmelee 237; Grashoff 337.* One large patch in NW part. Flowering May - June.

Viola canadensis L. Canada violet. *Anderson 2238; Gillis 2655; Popma 331.* Abundant throughout the woods. Flowering mostly in May and June but sporadically from April to October.

V. pubescens var. *eriocarpa* (Schwein.) Russell. Yellow violet. *Anderson 2231; Hubbard 32.* Scattered through the woods. Flowering April - June.

V. rostrata Pursh. Long-spurred violet. *Anderson 2237.* Infrequent. Flowering April - May.

V. sororia Willd. Blue violet. *Anderson 2236; Hubbard 23, 26; Stergios 19.* Scattered through the woods. Flowering April - June.

V. striata Ait. Cream violet. *Stergios 20.* Infrequent. Flowering April - July, most abundantly in May.

CUCURBITACEAE (Gourd Family)

Echinocystis lobata (Michx.) T. & G. Prickly cucumber. *Nelson 245.* Near the river in NW portion; rare. Flowering in August.

SALICACEAE (Willow Family)

Populus deltoides Marsh. Cottonwood. *Nelson 169.* By the river, on the E edge and at sugar house site. Flowering April - May.

P. grandidentata Michx. Large-tooth aspen. *Nelson 256.* Small tree at sugar house site. Flowering in May.

P. tremuloides Michx. Quaking aspen. *Nelson 190.* Small tree at sugar house site. Flowering in April.

Salix amygdaloides Anderss. Peach-leaved willow. *Valasek 429.* On road bank at E edge. Flowering May - June.

S. discolor Muhl. Pussy willow. *Morse 6976.* On E edge. Flowering April - May.

S. fragilis L. Crack willow. *Morse 6968.* Introduced; on small mud flat, S bank of river. Flowering April - May.

S. interior Rowlee. Sandbar willow. *Nelson 211.* On road bank at E edge. Flowering May - June.

S. rigida Muhl. Heart-leaved willow. *Valasek 428.* Swampy open area near E edge. Flowering April - May.

CRUCIFERAE (Mustard Family)

Arabis laevigata (Muhl.) Poir. Rock cress. *Grashoff 331; Hubbard 52.* Scattered through the woods on sandy soil. Flowering May - June.

Barbarea vulgaris R. Br. Winter cress or yellow rocket. *Grashoff 324; Hubbard 57.* Introduced weed, infrequent at edge. Flowering May - August.

Berteroa incana (L.) DC. Hoary alyssum. *Nelson 212.* Introduced weed, infrequent at edge. Flowering June - early November.

Brassica campestris L. Field mustard. *Nelson 208.* Introduced weed, infrequent in open, disturbed areas. Flowering May - August.

Capsella bursa-pastoris (L.) Medic. Shepherd's purse. *Grashoff 340.* Introduced weed, infrequent in disturbed areas. Flowering May - October.

Cardamine bulbosa (Schreb.) BSP. Spring cress. *Grashoff 284, 335; Hubbard 51.* In low wet areas near vernal pools. Flowering April - early June.

C. douglassii (Torr.) Britton. Bitter cress. *Hubbard 13.* In low wet areas near vernal pools. Flowering April - May.

Dentaria laciniata Muhl. Toothwort. *Hubbard 14.* Common throughout the upland portion. Flowering April - May.

Erysimum cheiranthoides L. Wormseed-mustard. *Nelson 157.* Introduced; near the river. Flowering July - October.

Hesperis matronalis L. Dame's-violet. *Grashoff 325; Hubbard 61; Nelson 214.* Introduced; occasional near the river. Flowering May - July.

Lepidium campestre (L.) R. Br. Peppergrass. *Nelson 126.* Introduced weed at edge. Flowering May - June.

L. virginicum L. Peppergrass. *Nelson 224.* In open area at edge. Flowering May - July.

Sisymbrium officinale (L.) Scop. Hedge-mustard. *Nelson 222.* Introduced; in open area at edge. Flowering May - July.

PRIMULACEAE (Primrose Family)

Lysimachia ciliata L. Loosestrife. *Grashoff 2.* In low wet areas near the river. Flowering June - August.

L. nummularia L. Moneywort. *Malcolm* in 1957. Introduced; in low wet areas near the river. Flowering June - August.

Samolus parviflorus Raf. Water-pimpernel. *Anderson 2160.* On riverbank with *Saururus cernuus.* Flowering July - September.

ROSIDAE

GROSSULARIACEAE (Gooseberry Family)

Ribes cynosbati L. Prickly gooseberry. *Anderson 2285; Grashoff 305.* Scattered through the wood. Flowering in May.

R. sativum Syme. Red currant. *Grashoff 304; Hubbard 37; Stergios 15.* Introduced; near the river. Flowering in May. *Stergios 15* and *Grashoff 304* appear intermediate between this species and the native *R. triste* Pall.

SAXIFRAGACEAE (Saxifrage Family)

Mitella diphylla L. Bishop's cap. *Anderson 2284; Hubbard 39.* Scattered through the woods. Flowering late April - early June.

ROSACEAE (Rose Family)

Amelanchier laevis Wieg. Serviceberry. *Stergios 1.* On the riverbank; infrequent. Flowering late April - early June.

Crataegus macrosperma Ashe. Hawthorn. *Morse 6990, 6995.* N of Van Hoosen Hall and by fence NE of Holmes Hall. Flowering May - June.

C. mollis (T. & G.) Scheele. Hawthorn. *Valasek 436.* NE part. Flowering March - early June.

C. punctata Jacq. Hawthorn. *Nelson 104.* Infrequent; near the river. Flowering May - early June.

C. succulenta Link. Hawthorn. *Morse 6991; Nelson 115.* Infrequent; near the river. Flowering May - June.

Geum canadense Jacq. Avens. *Marshall 228; Nelson 171.* Scattered through the woods. Flowering June - August.

Potentilla recta L. Five-finger. *Nelson 133.* Introduced weed in open areas at edge. Flowering June - August.

Prunus serotina Ehrh. Black cherry. *Horning 19.* Scattered, mostly large trees. Flowering in May.

P. virginiana L. Choke cherry. *Grashoff 321; Nelson 221, 323.* Forming small thickets, especially near the W edge. Flowering May - early June.

Rubus allegheniensis Porter. Common blackberry. *Grashoff 333.* Infrequent; at edge. Flowering May - June.

R. occidentalis L. Black raspberry. *Grashoff 343; Hubbard 58.* In open areas. Flowering May - June.

R. strigosus Michx. Red raspberry. *Morse 6996.* Near the river at NE corner. Flowering June - July.

LEGUMINOSAE (Pea Family)

Amphicarpa bracteata (L.) Fern. Hog-peanut. This species has not been collected in Sanford Natural Area, but immature plants were observed there in June, 1968. They could not be relocated after the flood in late June. Flowering July - September.

Desmodium nudiflorum (L.) DC. Tick-trefoil. *Grashoff 28.* Scattered through the woods. Flowering July - August.

Gleditsia triacanthos L. Honey-locust. *Nelson 244.* Seedlings along the riverbank, probably from trees planted upriver. Flowering in June.

Gymnocladus dioica (L.) K. Koch. Kentucky coffee-tree. Noted in N-central part in 1895, cut down in 1896 and apparently not present since then. Flowering May - June.

Medicago lupulina L. Black medick. *Nelson 138.* Introduced weed at edge. Flowering June - September.

M. sativa L. Alfalfa. *Nelson 313.* Introduced weed on E side along road bank. Flowering June - September.

Melilotus alba Desr. White sweet-clover. *Nelson 120.* Introduced weed at edge. Flowering June - October.

M. officinalis (L.) Lam. Yellow sweet-clover. *Nelson 130.* Introduced weed at edge. Flowering June - September.

Robinia pseudo-acacia L. Black locust. *Grashoff 336.* Planted in 1896; several large trees in W-central portion and some smaller spontaneous individuals. Flowering May - June.

Trifolium hybridum L. Alsike clover. *Nelson 128, 180.* Introduced weed at edge. Flowering June - October.

THYMELAEACEAE (Mezereum Family)

Dirca palustris L. Leatherwood or moosewood. *Anderson 2228; Marshall 291.* Rare; a few shrubs scattered through the woods. Flowering late April - May.

ONAGRACEAE (Evening-primrose Family)

Circaea quadrisulcata var. *canadensis* (L.) Hara. Enchanter's nightshade. *Nelson 187.* Scattered throughout and very abundant in local areas. Flowering June - early August.

Oenothera biennis L. Evening primrose. *Nelson 241.* Weed in open area on the riverbank. Flowering July - September.

CORNACEAE (Dogwood Family)

Cornus alternifolia L. f. Alternate-leaved dogwood or green osier. *Grashoff 303.* Scattered through the woods. Flowering May - June.

C. amomum subsp. *obliqua* (Raf.) J. S. Wilson. Silky cornel or kinnikinnik. *Morse 6962, 6989, 6993; Nelson 167; Valasek 435.* On E side and NW corner. Flowering in June. *Morse 6993, Nelson 167,* and *Valasek 435* are from an apparently hybrid clone (× *C. foemina* subsp. *racemosa*) in the SE corner.

C. florida L. Flowering dogwood. *Nelson 147.* Infrequent in NW part. Flowering in May.

C. foemina subsp. *racemosa* (Lam.) J. S. Wilson. *Morse 6973; Valasek 431.* Near river in N-central and NE part. Flowering May - June.

C. stolonifera Michx. Red osier. Noted in 1895 in marshy area on SE edge, the present site of Holmes Hall, and on W wide. Flowering May - June, infrequently in July and August.

CELASTRACEAE (Staff Tree Family)

Celastrus scandens L. Climbing bittersweet. *Nelson 117.* In partially open disturbed areas near riverbank. Flowering May - June.

Euonymus atropurpureus Jacq. Burning bush or wahoo. Noted in 1895 but not located in recent years. Flowering June - July.

E. obovatus Nutt. Running strawberry-bush. *Anderson 2167; Grashoff 36, 332; Hubbard 48.* Scattered through the woods. Flowering May - June.

AQUIFOLIACEAE (Holly Family)

Ilex verticillata (L.) Gray. Black alder or winterberry. Noted in 1895 in marshy area on SE edge, the present site of Holmes Hall. Flowering June - July.

EUPHORBIACEAE (Spurge Family)

Acalypha rhomboidea Raf. Three-seeded mercury. *Anderson 2168.* On roadside at NE corner. Flowering August - September.

RHAMNACEAE (Buckthorn Family)

Rhamnus cathartica L. Common buckthorn. *Nelson 312.* Introduced; one small tree in NE corner. Flowering in May.

R. frangula L. Alder-buckthorn. *Nelson 140.* Introduced; a few shrubs on W side. Flowering May - June.

VITACEAE (Grape Family)

Parthenocissus quinquefolia (L.) Planch. Virginia creeper or American ivy. *Nelson 210.* Common throughout the woods. Flowering in June.

Vitis riparia Michx. Frost grape. *Nelson 170.* Near the river and at E edge. Flowering May - June.

STAPHYLEACEAE (Bladdernut Family)

Staphylea trifolia L. Bladdernut. *Hubbard 43; Janson* in 1950. Occasional on W side. Flowering May - June.

HIPPOCASTANACEAE (Horse-chestnut Family)

Aesculus hippocastanum L. Horse-chestnut. *Morse 6984.* Introduced; one shrubby small tree near W edge. Flowering in May.

ACERACEAE (Maple Family)

Acer negundo L. Box-elder. *Nelson 168.* Infrequent; at E edge. Flowering April - May.

A. nigrum Michx. f. Black maple. *Nelson 158.* Scattered through the woods but mostly near the river. Flowering April - early May. In this area the species shows much evidence of intergradation with *A. saccharum.*

A. platanoides L. Norway maple. *Morse 6431.* Introduced; seedling by path near S edge. Flowering April - May.

A. rubrum L. Red maple. *Nelson 146.* Infrequent, near the river. Flowering April-early May.

A. saccharinum L. Silver or white maple. *Nelson 106.* Frequent in wet areas near river. Flowering April - early May.

A. saccharum Marsh. Sugar or hard maple. *Nelson 159.* The dominant tree throughout most of the woods. Flowering April - May. Intergrading with *A. nigrum.*

ANACARDIACEAE (Cashew Family)

Rhus typhina L. Staghorn sumac. *Nelson 194.* In open area at the sugar house site. Flowering in June.

Toxicodendron radicans (L.) Ktze. Poison-ivy. *Gillis 6930.* Very abundant, especially near the river. Flowering in June.

T. vernix (L.) Ktze. Poison sumac. No specimens collected from Sanford Natural Area, but plants occurred on the site where Holmes Hall was constructed. Flowering June - July.

RUTACEAE (Rue Family)

Ptelea trifoliata L. Wafer-ash or hop tree. *Horning* in 1960; *Janson 69.* Occasional on W side in partially open areas. Flowering April - early June.

Zanthoxylum americanum Mill. Prickly-ash. *Grashoff 301.* Occasional near the river in NE portion. Flowering in May.

OXALIDACEAE (Wood-sorrel Family)

Oxalis stricta L. Wood-sorrel. *Nelson 143.* In open area at W edge; weedy. Flowering late May - August.

GERANIACEAE (Geranium Family)

Geranium maculatum L. Cranesbill. *Hubbard 38; Stergios 26.* Common throughout the woods. Flowering May - early June,

BALSAMINACEAE (Touch-me-not Family)

Impatiens noli-tangere subsp. *biflora* (Walt.) Hultén. Spotted touch-me-not. *Grashoff 40.* Occasional, mostly in areas where the soil is very wet. Flowering July - September.

ARALIACEAE (Ginseng Family)

Aralia racemosa L. Spikenard. *Gillis 2654; Nelson 192.* In open area at the sugar house site. Flowering in July.

Panax quinquefolius L. Ginseng. *Grashoff 44.* Wooded slope; extremely rare. Flowering May - early June.

P. trifolius L. Dwarf ginseng. *Ellsworth 85; Suttkus 31; Shipman 30.* In thickly wooded areas, rare. Flowering April - May.

UMBELLIFERAE (Parsley Family)

Cryptotaenia canadensis (Torr.) DC. Honewort. *Nelson 197.* Scattered through the woods. Flowering June - July.

Daucus carota L. Wild carrot or Queen Anne's lace. *Nelson 179.* Introduced weed at edge. Flowering June - October.

Erigenia bulbosa (Michx.) Nutt. Harbinger-of-spring. *Anderson 2216; Hubbard 3; Marshall 1521.* Infrequent; scattered through the woods. Flowering in April, the earliest species.

Osmorhiza claytonii (Michx.) C. B. Clark. Sweet cicely. *Hubbard 46; Nelson 205.* Scattered through the woods. Flowering May - June.

Sanicula gregaria Bickn. Black snakeroot. *Grashoff 327; Nelson 150, 320.* Scattered through the woods. Flowering May - early July.

S. trifoliata Bickn. Black snakeroot. *Nelson 321.* Infrequent in S-central part. Flowering late May - early July.

Sium suave Walt. Water-parsnip. *Gillis 2415; Grashoff 30.* Rare; on swampy riverbank. Flowering July - October.

Taenidia integerrima (L.) Drude. Yellow pimpernel. *Gillis 2447.* Collected from N bank of river adjacent to Sanford Natural Area, but apparently not obtained from within the area. Flowering in June.

Torilis japonica (Houtt.) DC. Hedge-parsley. *Nelson 272.* Introduced weed; on S edge. Flowering July - August.

ASTERIDAE

APOCYNACEAE (Dogbane Family)

Apocynum cannabinum L. Indian-hemp. *Nelson 239.* In open area on the riverbank at W edge. Flowering May - September.

ASCLEPIADACEAE (Milkweed Family)

Asclepias incarnata L. Swamp milkweed. *Grashoff 27.* In mucky soil near the river. Flowering June - August.

A. syriaca L. Common milkweed. *Nelson 278.* Weed at W edge. Flowering June - August.

Cynanchum nigrum (L.) Pers. *Nelson 118.* Introduced; in somewhat disturbed areas near W edge. Flowering May - July.

SOLANACEAE (Nightshade Family)

Physalis subglabrata Mackenz. & Bush. Ground-cherry. *Nelson 248.* In small ravine near W edge, rare. Flowering July - August.

Solanum dulcamara L. Red nightshade. *Nelson 315.* Introduced weed at E edge. Flowering June - mid August.

S. nigrum L. Black nightshade. *Nelson 225, 267.* Introduced weed in disturbed areas. Flowering July - early October.

POLEMONIACEAE (Phlox Family)

Phlox divaricata L. Phlox. *Hubbard 33; Stergios 27.* Common throughout the woods. Flowering April - June.

HYDROPHYLLACEAE (Waterleaf Family)

Hydrophyllum appendiculatum Michx. Waterleaf. *Grashoff 319.* Infrequent in the woods. Flowering May - July.

H. virginianum L. Waterleaf. *Grashoff 323; Hubbard 53.* Scattered through the woods. Flowering May - early June.

BORAGINACEAE (Borage Family)

Hackelia virginiana (L.) I. M. Johnst. Stickseed. *Gillis 2656; Nelson 247.* In semi-open, somewhat disturbed area. Flowering July - August.

Myosotis scorpioides L. Forget-me-not. *Grashoff 42; Hubbard 54; Nelson 173.* Introduced; in wet mucky soil near the river. Flowering May - October.

PHRYMACEAE (Lopseed Family)

Phryma leptostachya L. Lopseed. *Anderson 2157; Nelson 275.* Rare; in upland woods. Flowering June - August.

VERBENACEAE (Vervain Family)

Verbena urticifolia L. White vervain. *Grashoff 13.* Scattered through the woods, in some areas very abundant. Flowering July - early August.

LABIATAE (Mint Family)

Collinsonia canadensis L. Horse-balm. *Grashoff 39.* Scattered through the woods. Flowering August - early October.

Leonurus marrubiastrum L. Motherwort. *Valasek 403.* Introduced weed; on open riverbank at NW corner. Flowering August - September.

Lycopus virginicus L. Water-horehound. *Anderson 2202; Grashoff 29; Nelson 324.* In wet soil near the river. Flowering July - September.

Prunella vulgaris L. Heal-all. *Nelson 255.* Weedy, in open area at sugar house site. Flowering June - October.

Scutellaria lateriflora L. Mad-dog skullcap. *Grashoff 12; Nelson 250, 296.* In wet soil near the river. Flowering May - August.

Stachys tenuifolia Hedge-nettle. *Grashoff 14; Nelson 261, 283, 307.* In wet soil near the river. Flowering July - August.

Teucrium canadense L. Wood-sage. *Grashoff 9.* In road ditch at E edge. Flowering July - September.

PLANTAGINACEAE (Plantain Family)

Plantago lanceolata L. Ribgrass or buckhorn. *Nelson 135.* Introduced weed at edge. Flowering May - June.

P. major L. Common plantain. *Nelson 276.* Introduced weed in open disturbed area at E edge. Flowering July - October.

P. rugelii Dcne. Plantain. *Kaiser 238.* Infrequent. Flowering July - September.

OLEACEAE (Olive Family)

Fraxinus americana L. White ash. *Horning 15; Nelson 198.* One of the most common trees on the moister sites. Flowering in May.

F. nigra Marsh. Black ash. *Nelson 260, 311.* Near the river in NE portion. Flowering May - June.

F. quadrangulata Michx. Blue ash. *Morse 7000.* On W side, rare. Flowering in May.

Ligustrum vulgare L. Privet. *Valasek 426.* Introduced; on riverbank in N-central part. Flowering May - July.

SCROPHULARIACEAE (Figwort Family)

Chelone glabra L. Turtlehead. *Nelson 305.* In wet soil near the river. Flowering July - September.

Linaria vulgaris Hill. Toadflax. *Nelson 316.* Introduced weed, in open, disturbed soil at E edge. Flowering June - October.

Mimulus ringens L. Monkey-flower. *Grashoff 25.* In very wet soil near the river. Flowering late June - September.

Scrophularia marilandica L. Carpenter's-square. *Nelson 254.* In somewhat disturbed, shaded area at edge of sugar house site. Flowering June - July.

Verbascum thapsus L. Common mullein. *Nelson 218.* Introduced weed, in disturbed area at E edge. Flowering June - August.

Veronicastrum virginicum (L.) Farw. Culver's-root. *Grashoff 15.* In wet soil near the river. Flowering June - August.

OROBANCHACEAE (Broom-rape Family)

Epifagus virginiana (L.) Bart. Beech-drops. *Anderson 2204; Nelson 288.* Parasitic on beech, scattered through the woods. Flowering July - October.

CAMPANULACEAE (Bluebell Family)

Campanula americana L. Tall bellflower. *Grashoff 1; Nelson 228.* Scattered through the woods, very abundant in some areas. Flowering June - August.

Lobelia cardinalis L. Cardinal-flower. *Grashoff 11; Nelson 282.* In pools near the river. Flowering July - October.

L. syphilitica L. Blue cardinal-flower. *Grashoff 37, 38.* In very wet soil near the river. Flowering August - early October.

RUBIACEAE (Madder Family)

Cephalanthus occidentalis L. Buttonbush. *Nelson 253.* By intermittent lagoon in N-central portion. Flowering June - August.

Galium aparine L. Cleavers. *Hubbard 49.* Scattered through the woods. Flowering May - June.

G. circaezans Michx. Wild-licorice. *Nelson 162.* Infrequent. Flowering May - July.

G. obtusum Bigel. Bedstraw. *Nelson 172.* Infrequent; in open area at W edge. Flowering in June.

G. triflorum Michx. Sweet-scented bedstraw. *Nelson 148, 189.* Scattered through the woods. Flowering May - July.

Mitchella repens L. Partridge-berry. *Valasek 445.* Rare; one colony in NW portion near the river. Flowering June - July.

CAPRIFOLIACEAE (Honeysuckle Family)

Lonicera maackii Maxim. *Morse 6975.* Introduced; occasional throughout the woods. Flowering material of Michigan specimens lacking in the Beal-Darlington Herbarium.

L. tatarica L. Tatarian honeysuckle. *Grashoff 302.* Introduced; scattered through the woods. Flowering May - June.

L. xylosteum L. Fly honeysuckle. *Morse 6980.* Introduced; in W-central part. Flowering in May.

Sambucus canadensis L. Common elder. *Nelson 209.* At SE edge near vernal pool drained by road construction. Flowering June - early August.

S. pubens Michx. Red-berried elder. *Grashoff 295; Hubbard 41.* Scattered through the woods. Flowering late April - June.

Viburnum acerifolium L. Arrow-wood or maple-leaved viburnum. *Morse 6985; Parmelee 516.* Rare; near W edge. Flowering May - June.

V. lantana L. Wayfaring tree. *Grashoff 297.* Introduced; at W edge. Flowering May - June.

V. lentago L. Sheepberry or nannyberry. *Morse 7012.* Rare; one small shrub SW of sugar house site. Flowering May - June.

V. recognitum Fern. Arrow-wood. *Morse 6977; Nelson 156.* Rare in this woods and in Michigan. Near the river in N-central and E part. Flowering material of Michigan specimens lacking in the Beal-Darlington Herbarium.

V. trilobum Marsh. Highbush-cranberry. *Anderson 2368; Donahue 88; Grashoff 314, Hubbard 56.* Scattered through the woods, especially near the river. Flowering May - July.

DIPSACACEAE (Teasel Family)

Dipsacus laciniatus L. Teasel. *Nelson 193.* Introduced weed in open area at the sugar house site. Flowering July - August.

COMPOSITAE (Composite or Aster Family)

Achillea millefolium L. Common yarrow. *Nelson 136.* Introduced weed at W edge. Flowering May - October.

Ambrosia artemisiifolia L. Common ragweed. *Nelson 280.* Weed in disturbed areas around the edge. Flowering August - September.

A. trifida L. Great ragweed. *Nelson 238.* Common in some open areas, especially near riverbank. Flowering July - August.

Anthemis arvensis L. Corn-chamomile. *Nelson 223.* Introduced weed in open disturbed area at W edge. Flowering May - June.

Arctium minus (Hill) Bernh. Common burdock. *Nelson 195.* Introduced weed; scattered through the woods. Flowering July - August.

Aster cordifolius L. *Nelson 285, 325.* In partly open margin on W side. Flowering August - October.

A. lateriflorus (L.) Britt. Calico aster. *Nelson 291.* In partly open margin on W side. Flowering July - early October.

A. macrophyllus L. Large-leaved aster. *Miller 3015; Nelson 246.* Scattered through the woods. Flowering August - October.

A. pilosus Willd. *Nelson 290.* In partly open margin on W side. Flowering August - October.

Bidens cernua L. Stick-tight. *Nelson 297.* On riverbank in NW portion. Flowering August - October.

B. frondosa L. Beggar-ticks. *Nelson 294.* In wet soil on riverbank. Flowering July - September.

Cichorium intybus L. Common chicory. *Nelson 178.* Introduced weed; common around the edge. Flowering June - October.

Cirsium arvense (L.) Scop. Canada thistle. *Nelson 181.* Introduced weed in open area at W edge. Flowering July - October.

C. vulgare (Savi) Tenore. Bull thistle. *Nelson 268.* Introduced weed in open area along road bank at E edge. Flowering July - October.

Conyza canadensis (L.) Cronq. Horseweed. *Nelson 273, 310.* Weed at edge of woods and along riverbank. Flowering August - September.

Erigeron annuus (L.) Pers. Daisy-fleabane. *Nelson 101, 236.* Weed at edge of woods. Flowering June - early October.

E. philadelphicus L. Fleabane. *Grashoff 339; Hubbard 63.* In open areas at edge. Flowering May - June.

Eupatorium maculatum L. Joe-Pye-weed. *Valasek 402.* Infrequent on semi-open riverbank in N-central part. Flowering July - September.

E. purpureum L. Joe-Pye-weed. *Nelson 232.* Scattered through the woods. Flowering July - September.

E. rugosum Houtt. White snakeroot. *Nelson 231.* Scattered through the woods. Flowering July - early October.

Helianthus decapetalus L. Sunflower. *Nelson 219.* Abundant along open S edge. Flowering late July - early September.

Matricaria matricarioides (Less.) Porter. Pineapple-weed. *Nelson 227.* Introduced weed in open disturbed areas. Flowering June - September.

Polymnia canadensis L. Leafcup. *Grashoff 43; Miller 3017.* Infrequent in NE part. Flowering late May - October.

Prenanthes altissima L. Rattlesnake-root. *Nelson 322.* Scattered through the woods. Flowering July - October.

Rudbeckia laciniata L. Coneflower. *Nelson 281. 306.* In low very wet areas near the river. Flowering July - early October.

Solidago caesia L. Blue-stem goldenrod. *Nelson 286.* In partly open W edge. Flowering late August - early October.

S. canadensis L. Goldenrod. *Nelson 284, 289.* In open area at W edge. Flowering late July - October.

S. flexicaulis L. Goldenrod. *Anderson 2156; Nelson 230, 279, 287.* Along partly open W edge. Flowering July - September.

S. gigantea Ait. Goldenrod. *Nelson 326.* In wet area in N-central portion. Flowering August - September.

S. graminifolia (L.) Salisb. Goldenrod. *Nelson 292.* In open area at W edge. Flowering late July - September.

Sonchus arvensis L. Sow-thistle. *Nelson 265.* Introduced weed; on open road bank at E edge. Flowering July - October.

S. oleraceus L. Sow-thistle. *Nelson 274.* Introduced weed on S edge. Flowering June - August.

Taraxacum officinale Weber. Dandelion. *Grashoff 299; Stergios 10.* Introduced weed in open, disturbed areas. Flowering April - October.

LILIATAE (Monocotyledons)

ALISMATIDAE

ALISMATACEAE (Water-plantain Family)

Alisma plantago-aquatica var. *americanum* Roem. & Schult. Water-plantain. *Grashoff 26; Nelson 314.* In pools near the river in NE portion. Flowering July - August.

Sagittaria latifolia Willd. Arrowhead. *Grashoff 24.* Swampy ground near the river in NW portion. Flowering July - August.

HYDROCHARITACEAE (Frog's-bit Family)

Elodea nuttallii (Planch.) St. John. Waterweed. *Nelson 177.* In the river near Bogue Street Bridge and in vernal pools on the floodplain. Flowering July - August.

COMMELINIDAE

JUNCACEAE (Rush Family)

Juncus tenuis Willd. Path rush. *Nelson 145.* Near trail along river in N-central portion. Flowering June - August.

Luzula acuminata Raf. Wood rush. *Hubbard 21.* N side near river. Flowering April - May.

CYPERACEAE (Sedge Family)

Carex albursina Sheldon. *Anderson 2288.* Along paths at E end. Flowering May - July.

C. alopecoidea Tuckerm. *Nelson 182.* NW edge. Flowering June - July.

C. blanda Dewey. *Nelson 122.* NW corner by Bogue Street Bridge. Flowering May - June.

C. careyana Torr. *Grashoff 287; Marshall 296; Stergios 3.* Along path near river. Flowering April - June.

C. cephaloidea Dewey. *Grashoff 316.* Flowering May - early June.

C. convoluta Mackenzie. *Nelson 142.* NW edge. Flowering late May - July.

C. grayii Carey. *Anderson 2203; Hubbard 62.* N-central part in moist areas. Flowering June - August.

C. intumescens Rudge. *Hubbard 55.* Low area. Flowering May - July.

C. lupulina Muhl. *Nelson 216.* SE corner by former vernal pond. Flowering July - August.

C. molesta Mackenzie. *Nelson 123.* NW corner by Bogue Street Bridge. Flowering June - July.

C. muskingumensis Schwein. *Valasek 443.* Rare; edge of floodplain in N-central part. Flowering May - July.

C. pedunculata Muhl. *Valasek 441.* NE part near N trail. Flowering May - June.

C. plantaginea Lam. *Anderson 2218, 2287; Hubbard 15.* In E portion. Flowering April - May.

C. sprengelii Dewey. *Grashoff 310; Marshall 295.* Moist shady woods. Flowering April - June.

C. stricta var. *strictior* (Dewey) Carey. *Marshall 294.* Moist shady area. Flowering April - June.

C. woodii Dewey. *Matthews & Matthews 96; Stergios 4.* Along trail by river. Flowering April - May.

Eleocharis acicularis (L.) R. & S. Spike rush. *Valasek 438.* By intermittent lagoons in N-central part. Flowering June - September.

GRAMINEAE (Grass Family)

Agropyron repens (L.) Beauv. Quack grass. *Nelson 134, 229.* Introduced weed; along W edge N of Van Hoosen Hall. Flowering June - August.

Brachyelytrum erectum (Schreb.) Beauv. var. *erectum. Anderson 2159; Nelson 113, 243.* Scattered through the woods, mostly near the river. Flowering June - July.

Bromus inermis Leyss. Brome grass. *Grashoff 344.* Introduced weed on NW edge. Flowering June - July.

B. latiglumis (Shear) Hitchc. Brome grass. *Anderson 2163; Nelson 242.* NW corner. Flowering June - August.

B. purgans L. Brome grass. *Parmelee 289.* In the woods. Flowering July - August.

B. tectorum L. Brome grass. *Nelson 125.* Introduced weed near the river at NW corner. Flowering May - July.

Calamagrostis canadensis (Michx.) Nutt. *Parmelee 284.* Floodplain. Flowering July - August.

Cinna arundinacea L. Wood reed. *Anderson 2161; Nelson 258, 271.* By vernal ponds in central and SE portion. Flowering in August.

Dactylis glomerata L. Orchard grass. *Grashoff 338; Nelson 127.* Introduced weed at NW corner. Flowering June - August.

Echinochloa muricata (Beauv.) Fern. Barnyard grass. *Nelson 300.* On riverbank at NW corner. Flowering August - September.

Elymus riparius Wieg. Wild rye. *Nelson 235.* In open weedy area at edge. Flowering in August.

E. villosus Muhl. Wild rye. *Nelson 204.* Near trail along river in NW portion. Flowering July - August.

E. virginicus L. Wild rye. *Nelson 234, 263.* NE portion of floodplain and in weedy open edge. Flowering July - August.

Eragrostis pilosa (L.) Beauv. Love grass. *Popma 329.* Introduced weed on riverbank at NW corner. Flowering July - October.

Festuca obtusa Biehler. Fescue. *Nelson 220.* At sugar house site. Flowering June - July.

F. pratensis Huds. Meadow fescue. *Grashoff 334.* Introduced weed. Flowering June - August.

F. ovina L. Sheep fescue. *Grashoff 342; Nelson 124, 137.* Introduced weed in NW portion by Bogue Street Bridge and at sugar house site. Flowering May - July.

Glyceria striata (Lam.) Hitchc. Manna grass. *Nelson 151, 217.* Scattered through the woods. Flowering June - July.

Hystrix patula Moench. Bottle-brush grass. *Marshall 227; Nelson 132.* In NW portion. Flowering June - July.

Leersia virginica Willd. White grass. *Nelson 269.* E-central edge. Flowering August - September.

Lolium perenne L. English rye grass. *Nelson 129, 277.* Introduced weed, at NW and SW edges. Flowering June - August.

Muhlenbergia frondosa (Poir.) Fern. f. *commutata* (Scribn.) Fern. Muhly. *Nelson 303.* On riverbank at NW corner. Flowering August - September.

M. schreberi Gmel. Muhly. *Nelson 266.* E-central edge. Flowering August - September.

Oryzopsis racemosa (Sm.) Ricker. Rice grass. *Valasek 440.* N-central part near trail. Flowering in July.

Panicum capillare L. Witch grass. *Nelson 302.* NW portion on riverbank. Flowering July - September.

Phleum pratense L. Timothy. *Nelson 121.* Introduced weed at NW corner. Flowering June - August.

Poa alsodes Gray. *Grashoff 329; Hubbard 50.* N side along riverbank. Flowering May - June.

P. annua L. Spear grass. *Nelson 257.* Introduced weed at sugar house site. Flowering June - October.

P. nemoralis L. *Nelson 110.* On riverbank in NW section. Flowering June - August.

P. palustris L. Fowl meadow grass. *Nelson 264.* On riverbank in NE portion. Flowering July - August.

P. pratensis L. Kentucky blue grass. *Nelson 185, 233.* Introduced weed at NW corner. Flowering June - August.

Setaria glauca (L.) Beauv. Foxtail grass. *Nelson 293.* Introduced weed on riverbank near Bogue Street Bridge. Flowering July - September.

Sphenopholis intermedia (Rydb.) Rydb. *Grashoff 322; Nelson 111.* On riverbank in NW portion. Flowering in June.

ARECIDAE

ARACEAE (Arum Family)

Arisaema triphyllum (L.) Schott. Jack-in-the-pulpit or Indian turnip. *Anderson 2280, 2282; Hubbard 28.* Scattered through the woods. Flowering late April - June.

A. dracontium (L.) Schott. Green dragon. *Nelson 155.* N-central portion near the river in low, wet areas. Flowering May - June.

Symplocarpus foetidus (L.) Nutt. Skunk cabbage. *Anderson 2229; Hubbard 11.* Near river in NW portion and formerly abundant in marshy area on SE edge where Holmes Hall was constructed. Flowering in April.

LEMNACEAE (Duckweed Family)

Lemna minor L. Duckweed. *Nelson 176.* In river near Bogue Street Bridge, and in vernal pools on the floodplain. Flowering June - August.

LILIIDAE

LILIACEAE (Lily Family)

Allium tricoccum Ait. Wild leek. *Grashoff 41.* In W-central area and near river in N-central portion. Flowering July - August.

Asparagus officinalis L. Asparagus. *Nelson 317.* Introduced weed in E section on floodplain. Flowering May - June.

Erythronium albidum Nutt. White dog's-tooth-violet. *Hubbard 22.* N-central portion in wet area; rare. Flowering April - May.

E. americanum Ker. Yellow adder's tongue. *Anderson 2281; Grashoff 289; Hubbard 18.* Frequent in the woods. Flowering April - May.

Hemerocallis fulva L. Day lily. *Nelson 166.* Introduced weed in SE part. Flowering July - August.

Lilium michiganense Farw. Michigan lily. *Nelson 259.* N-central and NE floodplain; rare. Flowering June - July.

Maianthemum canadense Desf. Canada mayflower. *Nelson 186* (var. *interius* Fern.); *Suttkus 63* (var. *canadense*). Near the river. Flowering May - June.

Polygonatum pubescens (Willd.) Pursh. Small Solomon's seal. *Anderson 2283.* Scattered through the woods. Flowering May - June.

Smilacina racemosa (L.) Desf. False Solomon's seal. *Hubbard 47.* Scattered through the woods. Flowering May - June.

S. stellata (L.) Desf. False Solomon's seal. *Hubbard 40.* Scattered through the woods. Flowering May - June.

Trillium grandiflorum (Michx.) Salisb. Trillium. *Hubbard 31; Matthews 101.* Frequent throughout the woods. Flowering April - May.

Uvularia grandiflora Sm. Bellwort. *Anderson 2258; Grashoff 290; Hubbard 29.* Scattered through the woods. Flowering April - May.

IRIDACEAE (Iris Family)

Iris virginica var. *shrevei* (Small) Anderson. Iris. *Grashoff 312.* By intermittent lagoons in N-central portion. Flowering in June.

SMILACACEAE (Greenbrier Family)

Smilax ecirrata (Engelm. ex Kunth) S. Wats. *Hubbard 36.* Near the river. Flowering in May.

S. illinoensis Mangaly. *Gillett 606; Grashoff 326.* NW part. Flowering May - June.

S. tamnoides var. *hispida* (Muhl.) Fern. Bristly greenbrier. *Grashoff 313; Nelson 114.* NW portion near the river. Flowering in June.

DIOSCOREACEAE (Yam Family)

Dioscorea villosa L. Wild yam. *Nelson 174, 202.* By intermittent lagoons in N-central portion. Flowering June - July.

ORCHIDACEAE (Orchid Family)

Aplectrum hyemale (Muhl.) Torr. Adam-and-Eve. *Gilly & Parmelee 236.* Rare. Flowering May - June.

Corallorhiza maculata Raf. Coral-root. *H. Miller* in 1967. In NW portion near trail; rare. Flowering July - August.

Epipactis helleborine (L.) Crantz. Helleborine. *Marshall 27.* Introduced; near the river. Flowering July - August.

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Reviews

HOW TO KNOW POLLEN AND SPORES. By Ronald O. Kapp. Wm. C. Brown Co., Dubuque. 1969. 249 pp. $3.25 (spiral); $4.00 (cloth).

This is in some ways a frustrating book, but one which will be useful to most American palynologists. It could have been very much better and more useful if the micro-morphology of the pollen were described more carefully, if the drawings were more detailed, and if greater care had been taken in editing. A serious mistake in editing is the reproduction of the numerous sketches in the key at different magnifications. This gives a misleading impression of the relative sizes of different pollen and spores. Pollen from four species of oak, for example, that differs in size by 30% at the most, is illustrated on the same page by drawings which differ in size by a factor of two.

The book begins with a general discussion of the morphology and function of pollen grains and spores, and with a very brief description of sampling and preparation techniques. The description of exine morphology is quite clear, but is incomplete in failing to describe "LO analysis." This technique, involving study of the exine under high magnification at different levels of focus to interpret 3-dimensional structures, is given only a brief definition in the glossary and index that appears at the end of the book. Yet it is essential for distinguishing pitted structures in the exine from raised structures. These very different kinds of structure are frequently confused at low magnification by inexperienced palynologists. The same difficulty arises with the illustrations, which are inconsistent; they should show structure with stippling and spaces unstippled (e.g., *both Salix* (fig. 191) and *Rorippa* (fig. 194) have a raised netlike structure, but this is stippled in *Salix* and light in *Rorippa*). Although the key is easy to follow, since variable types or types that are difficult to interpret are repeated in appropriate sections, the author is unclear in his written descriptions of the fine structure of pollen exines. I would argue, to give a few examples, with his description of *Potamogeton* as tectate, *Dryas* as psilate, *Acer pensylvanicum* as intectate.

The main usefulness of the book will be to direct American palynologists to the family or genus in which to look for analogs to unknown fossil grains. The drawings and descriptions will indicate possible identifications, although they should *not* be used themselves for identifications. Kapp cautions that palynologists must have available reference collections prepared from authoritatively identified plants. He has done us all a service by including in this treatment spores from mosses and fungi, as well as algae and protozoans that are frequently confused with pollen grains.

—M. B. Davis

PLANTS OF THE CHICAGO REGION A Check List of the Vascular Flora of the Chicago Region with Notes on Local Distribution and Ecology. By Floyd Swink. Morton Arboretum, Lisle, Illinois. 1969. 445 pp. $8.50.

The distribution of each species is indicated, largely by maps, for 22 counties around the head of Lake Michigan, from three in southeastern Wisconsin to Berrien County, Michigan. The introduction makes clear exactly what the book intends to do (and not to do) and lucidly explains the style and conventions employed. The work is based on critical evaluation of both specimens and literature reports. Perhaps its major original contribution is extensive listing of associated species and habitat preferences. The species are in one alphabetical list, with cross-references by synonyms and common names; all included genera, however, are listed under family names on pp. xvii-xxii. Nomenclaturists will regret the use of undesignated trinomials, although the introduction states that all are varieties. The volume is well bound and is reproduced very clearly from typed copy in a format easy to consult. I can recall examining no other book so closely without finding a single typographical error! The Morton Arboretum and its industrious taxonomist can justly be proud of this fine contribution to the local flora literature.

—E. G. V.

NATURAL PROLIFERATION OF FLOATING STEMS OF SCOURING-RUSH, *EQUISETUM HYEMALE*

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Scouring-rush, *Equisetum hyemale* L., is one of the most familiar plants of the northern hemisphere. Its colonies of rigid, upright, cone-tipped stems are scattered across an enormous range in northern Europe, Asia, and North America, in the New World running southward to Guatemala. The stems, with their gritty epidermis encrusted with silica tubercles, were used by our forebears for scouring pots and pans, and even today this or related species are used by poor people in other nations for this purpose. To the botanist, the scouring-rushes and their relatives, the horsetails, have special interest, for they represent the last survivors of a once prominent element of the world's flora. In the Coal Age, some of these plants grew as tall as modern trees, and there were a number of distinctive genera. There is today but a single genus with only 15 species.

Because they are unique among plants on the earth today, scouring-rushes and horsetails have received much attention from morphologists. They are completely isolated taxonomically, and any common ancestry with other living plants occurred at least several hundred million years ago.

Although we usually assume that scouring-rushes and horsetails reproduce by spores and gametophytes in a manner similar to the ferns, more and more evidence suggests that at least under certain circumstances, vegetative propagation may play an important role in forming new colonies. As anyone who has ever attempted to dig up a colony of scouring-rushes knows, the underground stems or rhizomes are rigid and fibrous, thicker than ordinary clothes rope. These rhizomes form extensive subterranean systems, often extending hundreds of feet along railroad embankments, lake shores, and the banks of streams. Thus, when one discovers a number of seemingly discrete colonies, say, along a highway shoulder, it is not necessarily true that they are separate colonies which originated from separate spores. All of the plants and all of the clumps may represent a single stock from a single fertilization.

An even more interesting mode of vegetative reproduction in scouring-rushes involves fragmentation of stems. Theoretically, if pieces of stem should be broken off, for one reason or another, and if they should float across a lake or down a river, it should be possible for them to found a new colony by settling on some damp shore and forming new roots and shoots. Contained within the nodes and inside the leaf sheaths are tissues which are still embryonic and capable of proliferating. It is these soft tissues which enable us

[1]We are indebted to the following persons for help in various ways: Peter Fajans, Richard Hauke, John Ludwig, Robert Sabo, Terry Sharik, Sylvia Taylor, and W. C. Wagner.

to pull the stems of scouring-rushes into separate units or internodes so easily. Each internode is attached to the node below it by a ring of delicate tissue, the intercalary meristem, which separates readily when pulled. This meristem is composed of more or less undifferentiated cells which are capable of dividing when properly stimulated. The occasional branched specimens of scouring-rush that we encounter in the field are caused by some injury to the apex or death of the apex; new side branches are then stimulated to form and these break through the sheaths. Such specimens have been given formal names ("f. *proliferum*" and "f. *polystachyum*") but they do not deserve such recognition, because they result from growth conditions, not truly genetic differences.

Hauke (1963) has theorized that the spread of hybrid scouring-rushes over long distances may be due to vegetative propagation by stem fragments. All known hybrids between species of scouring-rushes are sterile, and their spores are abortive, incapable of normal germination and growth; thus they cannot spread by spores. Hauke states that vegetative propagation via stem fragments may explain the existence of certain hybrids in places where one or both of the parents may be absent. For example, the sterile scouring-rush cross, *E.* ×*ferrissii* Clute, is an intermediate between common scouring-rush, *E. hyemale,* and the smooth scouring-rush, *E. laevigatum* A. Br. Its spores are abortive, and the cones fail to open. In the geographical regions where the two parental species grow together, the hybrid scouring-rush, as would be expected, is common, as in the Upper Great Lakes region. However, as Hauke has demonstrated, this hybrid is also present in regions where *E. laevigatum* is absent, indeed often at long distances from the range of that parent. There are records of *E.* ×*ferrissii* from Quebec and Connecticut south to Virginia, far east of the Ohio Valley localities at the easternmost edge of the range of *E. laevigatum.* Hauke hypothesizes that *E.* ×*ferrissii* exists in its eastern range because fragments of its stems were carried by rivers, by boats, or by becoming lodged in wheels of passing trains. If the fragments happened to fall in appropriate sites, they proliferated new plants and formed colonies. He performed experiments in which he showed that portions of the hybrid stem can be cut and planted in wet soil and will, in fact, produce new plants.

In this article we wish to report studies made during the summer and fall of 1969 of the occurrence of natural proliferation of stems of the common scouring-rush while floating in water. One of the consequences of our study is the conclusion that it is not necessary for a given segment of stem to be "planted," i.e., placed in soil, before it forms a new plant. If the means of dispersal of the stem fragment is via water—across a lake or down a stream—the fragment may well have proliferated and produced a plant before it is cast upon the appropriate shore situation for establishment. In other words, a new plant will be formed and ready for immediate rooting and growth.

FIELD OBSERVATIONS

In July, 1969, we encountered what appeared to be small plants of *Equisetum* growing directly out of the water of Dix Pond (Fig. 1) on the grounds of the Matthaei Botanical Gardens, due south of Dixboro, Washtenaw

County, Michigan. Closer examination revealed that the small plants were actually growing from the nodes of floating, detached stems of *E. hyemale* (Fig. 2). Further observations in Dix Pond revealed dozens of floating stem fragments of this species with all stages of development of new plants in evidence.

Scattered at different localities in the Matthaei Gardens natural areas are four taxa of *Equisetum:* Common horsetail, *E. arvense* L., is abundant in fields and woods; the water horsetail (or "pipes"), *E. fluviatile* L., is limited to wet, marshy spots in the woods along Fleming Creek. The only other scouring-rush beside *E. hyemale* that we have found thus far on the some 350 acres of the Gardens is a hybrid, *E.* ×*nelsonii* (A. A. Eat.) Schaffn. (= *E. laevigatum* × *variegatum*), known from a couple of localities along pond shores. (It is interesting to note that neither of the parents of the sterile *E.* ×*nelsonii* have been discovered in the Matthaei Gardens area.) Common scouring-rush, *E. hyemale,* is abundant in several areas, including the north end of Dix Pond.

Dix Pond is an artificial pond that resulted from the natural flooding of an old gravel pit. It is rectangular in outline, approximately 395 feet long, 120 feet wide, and has an average depth of 5 to 6 feet. The pond has occasionally been used for research purposes by University of Michigan biologists since the time the gravel pit operation was discontinued around 1950. Pine trees were planted during the period 1950-55 in the surrounding John Dix Field, but the vegetation bordering the pond is from natural seeding and has developed spontaneously. The trees and shrubs along the borders are shrubby St. John's-wort, *Hypericum prolificum,* the green ash, *Fraxinus pennsylvanica,* cottonwood, *Populus deltoides*, and several willows, *Salix* spp. Although the dry, open fields surrounding the pond contain mainly weedy and introduced species such as sweet-clovers, *Melilotus officinalis* and *M. alba,* star thistle, *Centaurea maculosa,* Queen Anne's lace, *Daucus carota,* and common milkweed, *Asclepias syriaca,* the banks of Dix Pond support mainly native aquatic or semi-aquatic plants—cattail, *Typha latifolia,* sedges, *Carex* spp., bulrush, *Scripus validus*, spike-rush, *Eleocharis* sp., and water-plantain, *Alisma triviale.* The scouring-rushes along the bank are accompanied by the more abundant and widespread field horsetail, *E. arvense.*

As our study of the natural proliferation of floating stems of the scouring-rush proceeded, it became evident that there were dozens of them, in some places forming such masses as to produce the appearance of a whole colony of small scouring-rushes growing out of the water. For the most part the stems which rose above the surface were not much more than 1 or 1.5 mm in thickness (Fig. 2). Below most of them, clusters of roots hung down into the water. Most remarkable was the fact that a few of the aerial stems, in spite of their size and slender habit, bore small strobili at their tips. Thus essentially complete, although miniature, plants could be formed from floating stem fragments, entirely without connection to soil. Specimens of various sizes and showing different forms of proliferations are illustrated in Figure 3.

Fig. 1. Border of Dix Pond, Matthaei Botanical Gardens, showing clones of scouring-rush along the shore.

Fig. 2. Floating culms of scouring-rush with upright shoots indicated by arrows. Roots hang into the water below. (Strip = 6 inches).

Our interest was further stimulated by the fact that there were *so many* stem fragments present on the pond surface. This suggested that some agent besides mere casual breaking off of stems was operating, and the clue to the cause was found by examining the broken tips. The majority of the fragments showed that the ends had obviously been chewed off—not merely separated at the nodes as one might expect. This led us to suspect that some mammal was involved, and it soon became evident that the animal in question was the muskrat. Eighteen muskrat tunnel entrances were subsequently located in Dix Pond, and the animal is obviously common here. Whether or not the muskrats here actually feed upon the scouring-rush fragments that they chew off is not known. The cutting of the plants may be merely a by-product of their clearing of paths to the *Typha* and *Scirpus,* which the muskrats do feed on, and of which practically every stem shows evidence of their chewing.

In order to gain some idea of the role of stem length and stem position in the origin of new plants from the floating fragments, we collected approximately 90 of them, and tabulated the number of nodes, the number and length of shoots and roots per node, and the positions of the nodes. All of the proliferations were found to arise from the nodes, i.e., from the intercalary meristems, and none occurred at the broken surfaces of internodes. All sizes of fragments were found to proliferate, even those with only two nodes (cf. Fig. 3, fragments on left). However, the larger fragments, those with 10 or more nodes, tended to show two phenomena: terminalization of the proliferations and polarity. The greatest amount of proliferation of any kind was toward the ends; the least amount in the middle (cf. Fig. 3, fragment on right). Also, the upper end of the fragment (as can be readily determined from the orientation of the sheaths) tends to produce mainly shoots, usually without any evident roots at all, while the lower end forms abundant roots as well as shoots (data tabulated in Tables 1 & 2). This polarity is extremely interesting in view of the fact that the fragments float in a horizontal plane. It suggests therefore that there is an inherent polarity independent of the orientation of the fragment: the morphologically basal part of the stem is more prone to proliferate complete plants with roots and shoots, and the morphologically apical part to proliferate only shoots.

EXPERIMENTAL OBSERVATIONS

To find how long it takes for the scouring-rushes to sprout while floating, as well as what conditions are needed and how much proliferation will occur under more or less controlled conditions, we placed fragments in different situations. These fragments were loosely tied with a string to a weight or naturally fixed object and left to float freely on the water surface. We selected sites that showed different combinations of slow and rapid current and shade and sun. In each site we used a sample of 14 stems, each consisting of the terminal internode plus 10 or 11 nodes. In each sample, 7 stems were cut at the node, and 7 between the nodes. The sites selected and the results of the experiments are shown in Table 3. To summarize the results, the following points should be made: (1) Within 6 days after fragments were

floated, they began to sprout. (2) Those in full sunlight sprouted first, but sprouting eventually occurred even in strong shade. (3) The sprouts were formed at the nodes, beneath the sheaths, but not in the internodes. (4) Still water is not necessary for proliferation, nor is flotation at the surface. Sprouts occurred even in rapid current, where the fragments became submerged. (5) Shoots up to 2 or more inches in length can be formed in only three weeks in the water. (6) Such rapidity of growth and differentiation of plants by natural proliferation suggest that many of them would be well prepared for establishment once they drifted to an appropriate land surface along the shore.

In another experiment we compared rates of production of proliferations in water with those on wet sand. On October 3, 1969, we collected approximately 40 culms and divided them into two groups. One group was floated in water, the other placed in wet sand on a misting bench in a research greenhouse. Those floated in water were adjacent to the culms on the mist bench. No changes were noticed until October 13, when 4 of the stems in the water, but only 1 on sand, showed primordial bulges. By October 21, all except one of those on water had formed distinct culms, but less than half of the stems on sand had evidence at all of proliferation, mainly as mere primordia. On October 24, *all* of the stems on water had definite shoots as well as roots; 75% of those on sand, in contrast, showed evidence of beginning root growth, but only a few specimens had shoots. These observations suggest that proliferation occurs more rapidly on water than on wet sand, at least under the conditions of our experiment.

DISCUSSION

We have described here the consequences of fragmentation by natural causes (cutting of culms by muskrats) of the common scouring-rush, *E. hyemale,* which gave rise to the flotation of numerous pieces on a small lake. These fragments proliferated shoots and/or roots at the nodes, some of these shoots even forming strobili at their apices. A tabulation of nearly 90 stem fragments revealed that all, even those with only two nodes, gave rise to proliferations. Large fragments with up to 10 or more nodes showed a tendency toward terminalization of the proliferations, as well as a distinctive polarity. Proliferation was greatest near the ends and least in the middle. The morphologically apical parts produced shoots but very few roots, but the basal parts produced both shoots and roots, indicating that an innate morphogenetic polarity is present that is unaffected by the horizontal orientation of the floating stem fragments. Experimental tests in selected aquatic sites revealed that well formed proliferations could arise in three weeks, that proliferation could occur in shade, in rapidly moving water, and even when the stem fragment was submerged. The muskrat has evidently not previously been reported as an agent in natural fragmentation in *Equisetum.* The ability of stem fragments to proliferate new plants entirely without connection to soil has apparently been previously overlooked.

Of what significance are these observations? It seems to us that the ability of the scouring-rush (and very likely related hybrids and species) to

form fairly well differentiated plants during flotation may have significance in the efficiency of asexual spread and establishment. Hauke (1963) has written (in regard to *E.* ×*nelsonii*) that

> In northern Michigan . . . where there are many lakes and rivers and hundreds of miles of sandy shores around the Great Lakes, [*E.* ×*nelsonii*] is perhaps the most widespread of all [scouring rushes], and seems to reproduce readily by fragmentation and water transport of the rhizomes. This mechanism was seen in action in Douglas Lake, Cheboygan Co., Michigan. At a place called "Pine Point," a sandy projection into the lake from its east shore, *E.* ×*nelsonii* was first collected in 1921. . . . In 1957 I went to the same locality and found it in abundance. Wave action was washing the sand away and rhizomes, attached to the shore, had sections up to one meter in length floating in the water. . . . It was apparent that a violent storm could tear off and scatter some of these.

Fig. 3. Dried specimens of proliferating culms of the scouring-rush. (See text). 1/5 × Natural Size.

TABLE 1. Data on 30 floating culms of *Equisetum.* Leftmost column, specimen no.; next column, length in cm. Node number base to apex along top. SHOOT classes: 1 = less than ½ cm; 2 = ½ – 3; 3 = 3 – 12; 4 = 12 or greater; * = strobili present. (Superscripts represent no. of shoot proliferations at each node.) ROOT Classes: 1 = under 1 cm; 2 = less than 10 roots up to 4 cm; 3 = 10 or more roots up to 4 cm or less than 5 roots over 4 cm; 4 = 10 roots, more than 5 over 5 cm; 5 = 10 or more roots over 4 cm.

SHOOTS

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	62	1'	2'	1'		2^3	1'	1^2	1'	1^3	1'	1'								
2	55		1'																	
3	54		1^2	1^2					1'	1'	1'									
4	67								1'	1'	1'									
5	55							1'	1'		1'	1'								
6	53			2^2	3^2															
7	50																			
8	57	2'	1'						1'	2^2	2'									
9	67																			
10	63	2^2	1'	1'			2'													
11	70									$*^2$	*'	*'								
12	59		1'																	
13	54								1^2	1'	1'									
14	34	1'						3'						3^2						
15	66	1'											1'	1'						
16	81												3^2	2'						
17	62	2^2								1'	3^2	3'								
18	74																			
19	63	1'																		
20	58	3^2										4'		3'						
21	72	3^2	3'		3^2				1'	1'	1'	3'		1'	1^2					
22	77		4^5												1'					
23	74	3^5	3^5	4^4	1'											1'				
24	77	2'	2^2		2^2					1'	1'		1'	1'	$*^2$					
25	55												2'							
26	85	3'	3^6											2'	1'	1'	2^2			
27	75	1^2	2'	2^3	2^2	2'	1'	1'	1^2	1^2	1'	1'								
28	89		1^2			1^2		1'						4^3	1'	1'				
29	75	2^3		3^2	3^2	3'	2'							1'			3'	3'	3^2	
30	46	2'												1'					2'	

ROOTS

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	62	2	2	1																
2	55																			
3	54		1																	
4	67		1	2	2		2	2		1										
5	55			1		1														
6	53			2	1															
7	50	2		2																
8	57	2	1																	
9	67										5									
10	63	3	1	2	1	2	2	1	1											
11	70	1		1			1													
12	59		1																	
13	54																			
14	34	1																		
15	66	2																		
16	81																			
17	62	3	2	1	1															
18	74	1	2	1	1															
19	63		2																	
20	58	4	2	2	2	2	2	2	2											
21	72	4	4	4	4															
22	77		4																	
23	74	4	4	4																
24	77	2	3		3		2	2					2		1					
25	55			2	3	4		3	2											
26	85	3	4	2	3	2			2	2		2	2							
27	75	2	2	3	2	1		1	1	2		1	1							
28	89		1	1		1		1	1											
29	75	4		4	3	3	2	2	1	1	2	2								
30	46	2																		

TABLE 2. Summary of shoot and root production at basal 4, apical 4, and medial nodes. Indices computed for shoots by multiplying classes by superscripts and summing products, for roots by summing classes.

	ROOTS		SHOOTS	
Nodes with proliferations Nodes without proliferations	$\frac{64}{120}$ = 53.3		$\frac{41}{120}$ = 34.2	BASAL 4 NODES
"	$\frac{39}{189}$ = 20.6		$\frac{35}{189}$ = 18.5	MEDIAL NODES
"	$\frac{3}{120}$ = 2.5		$\frac{41}{120}$ = 34.2	APICAL 4 NODES
TOTAL OF PROLIFERATION INDICES	= 140		= 191	BASAL 4 NODES
	= 68		= 75	MEDIAL NODES
	= 7		= 102	APICAL 4 NODES

TABLE 3. Summary of field experiments. Culms floated on August 14, 1969. N = no proliferations. P = initial protrusions. S = definite shoots.

Locality	Flow	Light	Aug. 18	Aug. 20	Sept. 3
Parker Brook Pond	Slow Moving	Full Sun	14 N	13 S, 1 P	(All lost)
Fleming Creek (Pool)	Slow Moving	Shade	14 N	10 P, 4 N	14 S (1 cm-2 cm)
Fleming Creek (Pool)	Rapid Current	Full Sun	14 N	11 N (3 lost)	11 S (1 cm-2 cm) (All submerged)
Fleming Creek (Pool)	Rapid Current	Shade	14 N	10 P, 4 N	14 S (3 cm-5 cm; one 13 cm)
Dix Pond	Still	Full Sun	14 N	12 S, 1 P, 1 N	14 S (3 cm-5 cm)

Thus Hauke suggests that rhizome fragments, torn off of wave-lashed shores, could serve as propagules. His experiments concerned with aerial stem sections demonstrated the potentiality of dispersal *without* rhizomes. However, he planted the artificially cut stems directly on or in more or less moist soil. Is such layering necessary for proliferation to be initiated? Our observations here suggest that whole plants, with shoot and root systems, can be formed during flotation—across a lake, down a canal or stream—and thus be immediately prepared for establishment once cast upon an appropriate shore site.

LITERATURE CITED

Hauke, Richard. 1963. A Taxonomic Monograph of the Genus Equisetum Subgenus Hippochaete. Nova Hedwigia Beih. 8. 123 pp.

CHANGES IN THE VASCULAR FLORA OF SEVEN SMALL ISLANDS IN WESTERN LAKE ERIE[1]

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Floristic studies of the herbaceous and woody plants growing without cultivation have been conducted for several or all of the islands in western Lake Erie by various authors during the past seventy years. Moseley (1899) published a flora of Erie County, Ohio, and included the peninsula and islands in Ottawa County, Ohio. A list of plants for each island cannot be prepared from Moseley's flora because he did not always cite the islands where each species was seen. Schaffner (1902) reported 15 species for Little Chicken Island. Kellerman (1904) listed 39 species for Hen Island, six species for Big Chicken Island, and 16 species for Little Chicken Island. For the latter two islands, the number of plants for each species was listed. Dodge (1914) prepared a flora of Point Pelee, Canada, and adjacent islands, taking records for the Ohio islands from Moseley (1899). Malcolm E. Stickney presented two papers entitled "The census of flowering plants on certain small islands of Lake Erie" and "The distribution of flowering plants on the smaller islands of Lake Erie" at meetings of the Ohio Academy of Science in 1921 and 1922, respectively (titles from Ohio Jour. Sci. 22: 19. 1921; 23: 23. 1923). Although Core (1948) used lists compiled by Stickney, neither a published nor a manuscript version of either of these papers has been located. Core listed 261 species from the seven small islands that are considered in this study. We have seen 231 species, 35 of which were not seen by Core.

Floras are continually in a state of flux and any contemporary floristic analysis should take into account those changes that have occurred through time, and the possible factors affecting those changes. In this paper, we compare the lists of plants prepared by Kellerman in 1903 (published in 1904) and by Core in 1939, 1940, and 1941 (published in 1948) with the records compiled by us during 1967, 1968, and 1969, in order to understand and possibly explain the floristic changes that have occurred on some of the small islands in western Lake Erie. These small islands are particularly desirable for a study in the dynamics of a flora, because the number of species on each island is few, and relatively complete lists for each island can be made.

During the summers of 1967, 1968, and 1969 inventories were prepared and collections were made of the vascular plants of Hen, Big Chicken, and Little Chicken Islands in Essex County, Ontario, Canada; and Lost Ballast,

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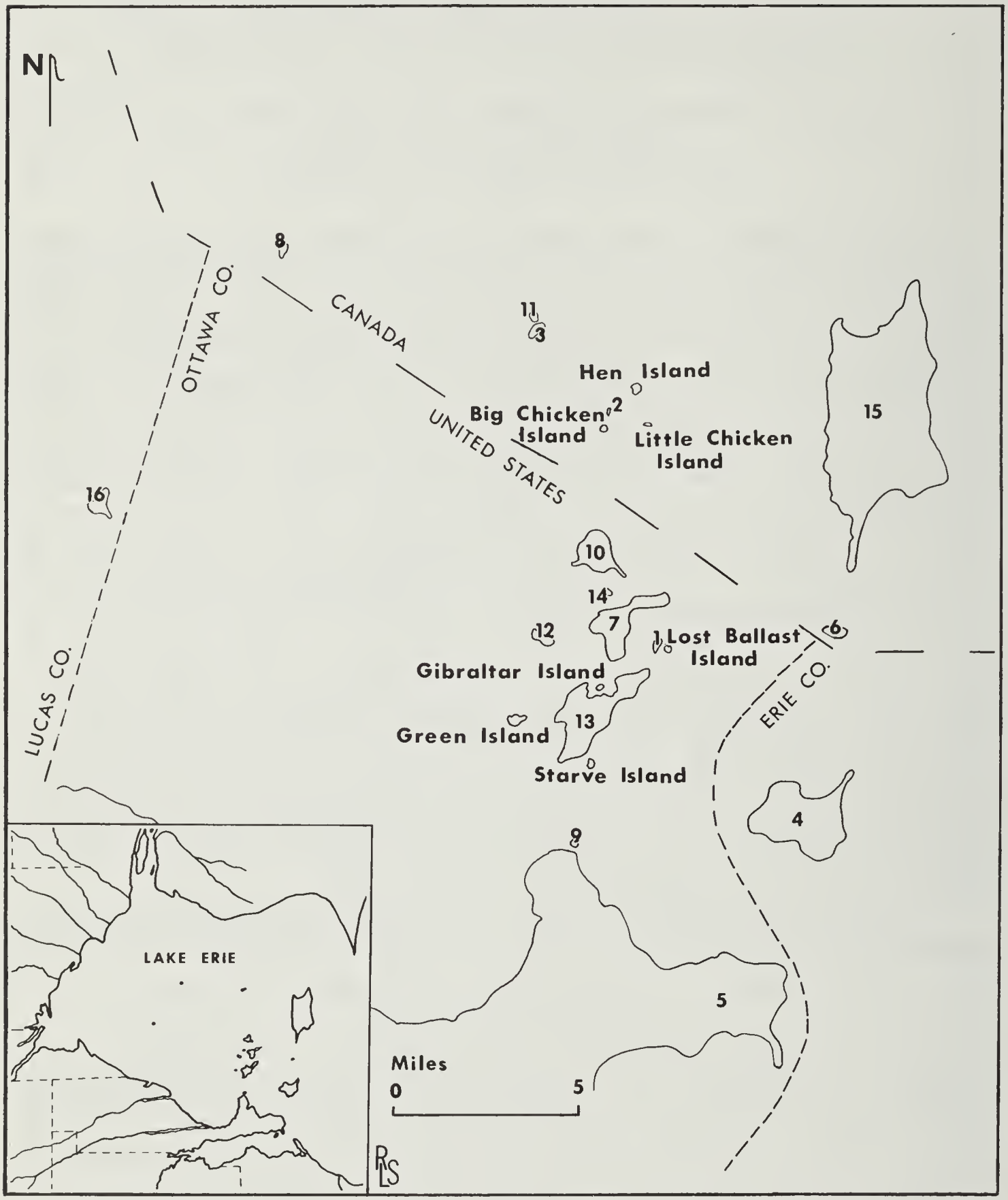

Fig. 1. Map of the islands in western Lake Erie. The small islands whose flora is discussed are labeled on the map. All of the other islands are designated according to the following numbers.

1 Ballast Island
2 Chick Island
3 East Sister Island
4 Kelleys Island
5 Marblehead Peninsula
6 Middle Island
7 Middle Bass Island
8 Middle Sister Island
9 Mouse Island
10 North Bass Island
11 North Harbor Island
12 Rattlesnake Island
13 South Bass Island
14 Sugar Island
15 Pelee Island
16 West Sister Island

Starve, Gibraltar, and Green Islands in Put-in-Bay Township, Ottawa County, Ohio (Fig. 1). During 1967 and 1968, Green Island was visited twice and Starve Island once. Additional records and specimens were obtained in 1967 from Starve Island by Billy Isom, Rachel Cox Downing, and Richard Deweese, and from Big Chicken Island by Jane L. Forsyth. In 1969, Lost Ballast Island was visited once; Hen, Big Chicken, Starve, and Little Chicken Islands were surveyed twice; and Green Island studied four times. The flora of Gibraltar Island was investigated frequently during all three summers because the Franz Theodore Stone Laboratory is located on this island. All specimens collected are in the herbarium of either The Ohio State University or the Franz Theodore Stone Laboratory. From the lists of plants, numbers and/or percentages for each island were calculated for (1) all species seen in our surveys, (2) the species reported by Kellerman (1904) and Core (1948) but not seen during our surveys, (3) the species not reported in any previous survey, (4) the non-indigenous species seen, and (5) the annuals, biennials, and perennials seen (tables 2-6).

DESCRIPTION OF THE ISLANDS

The islands in western Lake Erie were formed by erosion of preglacial streams from solid limestone [dolomite] bedrock (Carman, 1946). The bedrock of Starve, Gibraltar, and Green Islands is Put-in-Bay dolomite, whereas that of Lost Ballast, Little Chicken, Big Chicken, and Hen Islands is Raisin River dolomite (Carman, 1946). The islands are composed of gravel bars or beaches, rocky-shore cliffs, thin soil over dolomite bedrock, or a combination of these (Table 1). Lost Ballast, Little Chicken, Big Chicken, and Starve Islands are small, low, entirely (or partially) dolomitic gravel bar islands, whereas Hen, Gibraltar, and Green Islands are larger islands covered primarily with thin soil over dolomitic bedrock. These three islands have high steep rocky shore cliffs.

LOST BALLAST ISLAND

Lost Ballast Island is almost circular in outline, with a diameter of approximately 75 feet. The bedrock is covered with coarse gravel. In 1969, the island extended no more than one and a half feet above the surface of the

TABLE 1. Approximate Percentage of the Physiographic Areas on Each Island.

Physiographic Area	Island*						
	Lost Ballast	Little Chicken	Big Chicken (1)	Starve (2)	Hen (5¾)	Gibraltar (6)	Green (20)
Gravel bar or beach	100	100	100	50	10	10	–
Rocky-shore cliff	–	–	–	50	15	15	15
Thin soil over dolomite bedrock	–	–	–	–	75	75	85

*Numbers in parentheses indicate the approximate size of each island in acres.

Fig. 2. Starve Island; gravel bar in the foreground and shrubs of hackberry, willow, and dogwood in the background. Photographed on 13 July 1969 by Thomas Duncan.

Fig. 3. Gibraltar Island with high exposed north facing cliffs; surface of the island covered with woody vegetation. Photographed on 28 June 1969 by Thomas Duncan.

lake. Although Core (1948) reported several herbaceous species from this island, in 1969 only woody species were seen by us. At one time Lost Ballast Island was part of Ballast Island, but it was separated by wave action and heavy storms to the extent that now they are connected only by a submerged gravel bar (Ryall, 1913). The island has never been inhabited by man, but is the site of many herring gull nests.

LITTLE CHICKEN ISLAND

In 1969, Little Chicken Island was a bar of coarse gravel about 100 feet long extending one to two feet above the surface of the lake. The bedrock is covered primarily with angular rock fragments one to three inches in diameter (Kindle, 1937). Several herbaceous and a few woody species were reported by Jones (1902, 1912), Schaffner (1902), Kellerman (1904), and Core (1948), although in 1969 no species of vascular plants were present. In 1969, many herring gulls were observed on the island. Little Chicken Island has never been inhabited by man.

BIG CHICKEN ISLAND

In 1969, Big Chicken Island was approximately 300 feet long and extended about nine feet above the surface of the lake at the highest point. The bedrock of the island is covered primarily with slabby limestone [dolomite] pebbles from one to six inches in diameter (Kindle, 1937). Vegetation in the summer of 1969 was entirely herbaceous, although woody species were reported by Jones (1902, 1912), Kellerman (1904), and Core (1948). An eight-foot depression which is centrally located on the island contains a collapsed fishing building. Approximately one foot of water was in the depression in the summer of 1969, but no species of aquatic vascular plants were observed. Many pairs of cormorants and hundreds of herring gulls were nesting on the island. The island has been sporadically inhabited by man.

STARVE ISLAND

Starve Island is approximately two acres in area (Hatcher, 1945). In 1969, the island extended two feet above the surface of the lake at its highest point. The island is divided into two distinct parts by a gravel bar, which was submerged in July of 1969, but exposed in August (Fig. 2). Vascular plants were not seen on the bar at the latter time. The larger part of the island is approximately one and a third acres in area. About half of the bedrock is covered with coarse gravel. Glacial grooves are prominent on the south side of the island. The vegetation is composed of herbaceous and woody plants, with the former mostly on the gravel portion of the island. The island has never been inhabited by man. Many herring gull nests were observed in 1969.

HEN ISLAND

Hen Island contains an area of five and three-quarters acres (Kindle, 1937). It is surrounded by low rocky cliffs, at the base of which are five- to ten-foot shelves extending out and along the surface of the lake. Most of the

dolomite bedrock underlying the island is covered by a thin layer of soil, although outcrops were observed in several places. The Quinnebog Fishing Club, which purchased the island in 1888 (Ontario Department of Lands and Forests, pers. comm., 1969) has erected buildings and planted several herbaceous and woody species, some of which have escaped cultivation. Some areas of the island have remained forested, although these areas are now crossed with winding paths.

GIBRALTAR ISLAND

Gibraltar Island covers an area of six acres (Core, 1948). Rocky cliffs occur on the west, northwest, and north sides of the island (Fig. 3). On the southwest corner is Alligator Bar. This bar, approximately 100 feet of which is usually above the surface of the lake, extends from Gibraltar Island to South Bass Island and separates Fishery Bay and Squaw Harbor. The interior of the island is a lawn which is continually mowed and where many non-indigenous species occur. Small stands of trees are located on the northeast and northwest corners of the island. Trees also occur at various places throughout the lawn area. The island was purchased from J. D. Rivera St. Jago in 1864 by Jay Cooke who then constructed a mansion (Cooke Castle), which is still standing. He, his family, and guests used the island and mansion as a summer home until 1905 (Pollard, 1935). In 1925, the island was purchased by Julius F. Stone, who donated it to The Ohio State University (Langlois, 1949). Since 1925, the island has been the headquarters of the Franz Theodore Stone Laboratory.

GREEN ISLAND

Green Island is approximately 20 acres in area (Ryall, 1913). The island is surrounded by cliffs and rocky shores similar to those on Hen Island. The soil is very black, generally six to eight inches deep (Core, 1948). Although the island is covered primarily by woody vegetation of secondary successional growth, leaf litter is practically destroyed by the large snail population and heavy winter storms (Stansbery, personal communcation, 1969). According to a notation on an 1835 map (of which a copy has been supplied by Jack McCormick), the island was purchased in 1853 by the United States government. Green Island was occupied by a lighthouse keeper and his family from about 1860 (Ryall, 1913) until about 1919 (Nate Ladd, pers. comm., 1969). The house and remnants of the barn and boathouse used by these people still remain. During the summers prior to World War II, the island was occupied by a doctor and his family (Robert Dodge, pers. comm., 1969).

CHANGES IN THE TOTAL FLORA[2]

The vascular flora on each one of four small islands (Starve, Hen, Gibraltar, and Green) is undergoing change to the extent that 30-40% of the

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[2]In the discussion below we have chosen 1903, 1939, and 1969 as the reference years (the years of the most extensive work) when making comparisons. However, it should be understood that Core's records and our records are for three-year periods as mentioned in the introduction.

TABLE 2. Changes in the Total Flora.

Island	Lost Ballast	Little Chicken	Big Chicken	Starve	Hen	Gibraltar	Green
Number of species seen in:							
1903	–	16	6	–	39	–	–
1939	38	18	12	38	68	163	185
1969	14	0	15	63	80	144	138
Percentage of the flora of:*							
1903 not seen in 1939	–	62 (10)	50 (3)	–	30 (12)	–	–
1903 not seen in 1969	–	100 (16)	83 (5)	–	44 (17)	–	–
1939 not seen in 1969	68 (26)	100 (18)	67 (8)	30 (11)	40 (26)	30 (50)	34 (64)
Percentage of the flora which were new records in:							
1939	–	75 (12)	75 (9)	–	60 (41)	–	–
1969	13 (2)	0 (0)	73 (11)	57 (36)	44 (35)	23 (31)	13 (17)

*The actual number of species is given in parentheses beneath each percentage.

species seen in 1939 were not seen in 1969 (Table 2). More drastic floristic changes have occurred on Lost Ballast and the Chicken Islands, where 68% of the species seen in 1939 on Lost Ballast Island and 67% of the species in 1939 on Big Chicken Island were not seen in 1969. All of the vascular flora has disappeared from Little Chicken Island. Considering the flora as a whole for these seven islands, 261 species were noted in 1939, of which only 196 were found in 1969, for a 25% reduction in the total flora. This percentage is lower than that for any one island, because some species which have disappeared from all of the islands where they were seen in 1939 were seen in 1969 on one or more of the other islands.

Lost Ballast and Little Chicken Islands have undergone a similar change in that between 1939 and 1969 all of the herbaceous species have disappeared. The disappearance of these herbaceous species probably occurred during a much shorter period of time. This change could have happened during any one year in which there was strong wave erosion, high water level, or destructive ice action. Winds and wave action during storms, which can change the water level of the lake as much as four feet (Langlois, 1965a), would inundate these islands and destroy the plants. The short period of time in which the amount of vegetation can change on a gravel bar in the Lake Erie island area has been documented (Langlois, 1965b). For example, during periods of high water, the gravel bar between South Bass Island and its northeast point, Buckeye Island, or Buckeye Point, is inundated and its vegetation eradicated. After two or three subsequent years of low water level, the bar becomes revegetated (Langlois, 1965b). Chick Island, or Chicken Reef, located

northeast of Big Chicken Island, was covered with a dense stand of *Polygonum* sp. in 1901 (Jones, 1902, 1912), but these plants had disappeared by 1903 (Kellerman, 1904). During this two-year period, wave erosion and ice action, accompanied by a one-foot rise in mean water level (U. S. Lake Survey, 1969), was probably sufficient to eradicate the vegetation. In 1969, a year of high water level, Chick Island was no more than a few boulders protruding above the surface of the water.

The flora of both Little Chicken and Big Chicken Islands has undergone considerable flux over the past 70 years. For example, on Little Chicken Island, 62% of the species seen in 1903 by Kellerman were not seen in 1939 by Core, and none of these species were seen by us. On Big Chicken Island, 50% of the species seen in 1903 by Kellerman were not seen by Core in 1939, and 67% of the species noted in 1939 by Core and 83% of the species noted in 1903 by Kellerman were not seen by us. In 1903, Big Chicken Island had six species and in 1969, 15 species were present. The survival of a flora on Big Chicken Island, especially during a year of high water level as occurred in 1969, and not on Little Chicken Island is apparently related to certain physiographic features of Big Chicken Island that are not present on Little Chicken Island. Big Chicken Island is partially protected from wave erosion and ice action by a gravel storm beach extending approximately nine feet above the surface of the lake on the northeast side of the island. Behind the storm beach the surface slopes to the southwest where plants are in a habitat which is not directly exposed to severe northeast storms. Little Chicken Island, however, is but a ridge of gravel lying in an east-west direction which extends approximately two feet (in 1969) above the surface of the water. Its position is particularly vulnerable to the destructive action of storms.

A history of some of the species on Big Chicken and Little Chicken Islands can be reconstructed for the years between 1901 and 1969. The bur cucumber, *Sicyos angulatus,* one of the most abundant plants on Big Chicken Island in 1969, was seen there by Jones in 1901. Kellerman (1904) reported 75 small plants of this species. Since then, Kennedy (1922), Core (1948), and Forsyth (specimen label, 1967, OS) have stated that the bur cucumber is one of the predominant species on Big Chicken Island. One box-elder maple, *Acer negundo,* 12 inches high was reported by Kellerman on Big Chicken Island. Core also listed this species for Big Chicken Island. Forsyth (specimen label, 1967, OS) noted a small bent over, beaten tree. In 1969, *Acer negundo* was seen by members of the ornithology class from the Franz Theodore Stone Laboratory during the latter part of June, but the tree was not seen by us in the later part of July. The tree probably was blown away during the severe storm of 4 July 1969. The most abundant species on Big Chicken Island in 1969 was *Lepidium virginicum,* pepper-grass, an annual weed. It was not seen on the island in 1903 by Kellerman, but was reported by Core (1948). On Little Chicken Island, *Salix amygdaloides,* peach-leaved willow, was seen by Jones in 1901, and Kellerman reported 50 trees of varying sizes. Kindle (1937) and Core also reported this species, but the peach-leaved willow was not present in 1969.

The small gravel bar islands, Lost Ballast, Little Chicken, Big Chicken, and Starve, are not only disturbed by the waves and ice, but they are also inhabited by large concentrations of herring gulls and other shore birds during the summer. The large number of birds probably provides a significant means for the dissemination of plant propagules to the islands. The large amount of guano left on the islands could be significant for the survival of many of the plant species and account for some of the changes noted in species composition.

From 1939 to 1969, the number of species has increased from 38 to 63 on Starve Island and from 68 to 80 on Hen Island. Conversely, on Gibraltar Island and Green Island, the number of species has decreased from 163 to 144 and from 185 to 138, respectively. However, if a comparison is made between the number of species present in 1939 with the number of those same species present now, we find that 30-40% of these species on each one of these four islands have disappeared (Table 2). The reasons for these changes are not evident when viewing the total flora, but apparent reasons can be suggested by a study of the relationships between the longevity of the plants, their status in the flora, and the disturbance that occurs on these islands.

RELATIONSHIPS BETWEEN LONGEVITY OF PLANTS, THEIR STATUS IN THE FLORA, AND DISTURBANCE

The longevity (annual, biennial, or perennial) and apparent status (indigenous or non-indigenous) of each species in the flora are included in Table 6. The percentage of annuals has increased substantially between 1939 and 1969 on Big Chicken, Starve, and Hen Islands; has remained the same on Gibraltar Island; and has decreased slightly on Green Island (Table 3). From 1939 to 1969, the percentage of non-indigenous species has increased considerably on three of the islands, Big Chicken, Starve, and Hen (Table 3). The percentage of non-indigenous species has increased slightly on Gibraltar Island, and has remained the same on Green Island (Table 3).

On two of the small gravel bar islands, Big Chicken and Starve, the non-indigenous species are primarily annuals, whereas the indigenous species are mostly perennials (Table 4). One would expect a short-lived annual to survive and reproduce in a disturbed habitat more favorably than a perennial. Based on the percentage of species that have apparently invaded (numbers of new records) since 1939, a trend exists toward the elimination of the indigenous perennials and the invasion and establishment of non-indigenous annuals. For example, 55% of the new records for Big Chicken Island are non-indigenous annuals and none are indigenous perennials (Table 5). Indigenous perennials such as *Acer negundo, Celtis occidentalis, Sambucus canadensis, Scirpus fluviatilis, Urtica dioica,* and *Verbena hastata* have disappeared. Non-indigenous annuals such as *Amaranthus retroflexus, Capsella bursa-pastoris, Chenopodium album, Digitaria sanguinalis, Lactuca scariola, Portulaca oleracea, Sonchus arvensis,* and *S. asper* constitute the majority of the present flora. Starve Island, whose area is about half gravel bar, is showing a trend toward an increase in both indigenous and non-indigenous annuals and a de-

TABLE 3. Changes Related to the Longevity of the Plants and their Status in the Flora.

Island	Lost Ballast	Little Chicken	Big Chicken	Starve	Hen	Gibraltar	Green
Percentage of the flora which was:*							
a) non-indigenous species in:							
1903	–	12 (2)	17 (1)	–	29 (11)	–	–
1939	24 (9)	39 (7)	50 (6)	26 (10)	30 (22)	34 (55)	26 (48)
1969	22 (3)	0 (0)	73 (11)	40 (25)	48 (38)	37 (54)	26 (36)
b) annuals in:							
1903	–	62 (10)	17 (1)	–	23 (9)	–	–
1939	32 (12)	44 (8)	50 (6)	24 (9)	16 (11)	26 (42)	18 (34)
1969	0 (0)	0 (0)	80 (12)	44 (28)	34 (27)	26 (37)	14 (19)
c) perennials in:							
1903	–	38 (6)	83 (5)	–	72 (28)	–	–
1939	68 (26)	56 (10)	42 (5)	74 (28)	81 (55)	71 (116)	78 (144)
1969	100 (14)	0 (0)	13 (2)	52 (33)	62 (50)	70 (101)	80 (111)
d) biennials in:							
1903	–	0 (0)	0 (0)	–	5 (2)	–	–
1939	0 (0)	0 (0)	8 (1)	3 (1)	3 (2)	3 (5)	4 (7)
1969	0 (0)	0 (0)	7 (1)	3 (2)	4 (3)	4 (6)	6 (8)

*The actual number of species is given in parentheses beneath each percentage.

crease in both indigenous and non-indigenous perennials. Of the species that are listed as new records for Starve Island in 1969, 53% are annuals and 45% are perennials (Table 5). The gravel bar habitat of Starve Island, located mostly in the center of the island, is apparently less disturbed than Big Chicken Island. Another part of Starve Island, namely the bedrock shore, is considerably disturbed. Compared to Big Chicken Island, the percentage of invading non-indigenous annuals has been lower on Starve Island (Table 5).

On the three larger islands, Hen, Gibraltar, and Green, the non-indigenous species are both annuals and perennials and the indigenous species are mostly perennials (Table 4). Perennials, once established, would have a better

TABLE 4. Longevity of Non-Indigenous and Indigenous Species

Island	Lost Ballast	Little Chicken	Big Chicken	Starve	Hen	Gibraltar	Green
Percentage of non-indigenous species which were annuals in:*							
1903	–	50 (1-2)	0 (0-1)	–	55 (6-11)	–	–
1939	33 (3-9)	43 (3-7)	50 (3-6)	50 (5-10)	27 (6-22)	43 (23-55)	28 (17-48)
1969	0 (0-3)	0 (0-0)	73 (8-11)	60 (15-25)	42 (16-38)	43 (23-54)	33 (11-36)
Percentage of indigenous species which were perennials in:**							
1903	–	36 (5-14)	80 (4-5)	–	86 (24-28)	–	–
1939	79 (22-28)	45 (5-11)	50 (3-6)	86 (24-28)	80 (37-46)	83 (90-108)	85 (117-137)
1969	100 (11-11)	0 (0-0)	0 (0-5)	68 (26-38)	80 (33-41)	73 (69-94)	89 (91-102)

*The first number in parentheses is the number of non-indigenous annuals and the second is the total number of non-indigenous species.

**The first number in parentheses is the number of indigenous perennials and the second is the total number of indigenous species.

chance of surviving on these larger islands because the surface is little disturbed by wave erosion and ice action. Although man has had considerable influence on these larger islands, his actions have probably not disturbed the entire islands to the extent that the small gravel bar islands have been disturbed by environmental influences. The overall decrease in the number of species for Gibraltar Island is probably a result of continued cutting, maintaining, and opening of the habitat by the staff of the Franz Theodore Stone Laboratory. The non-indigenous component of the flora has been rather stable over the past 30 years (Table 3), with the greatest fluctuation probably occurring with the occupancy of the island by The Ohio State University personnel during the years immediately following the establishment of the laboratory. The species that have moved in over the past 30 years are mostly perennials (20 of 31 new records, or 64%, Table 5).

Although Core (1948) stated that Green Island has the closest approximation to the natural vegetation of any island, the 1885 map shows that 7.21 acres (42% of the island) were occupied by pasture, lawn, or garden. Therefore, a larger non-indigenous species component probably existed at the turn of the century or before, than has occurred on the island since man left in 1919. With increased secondary successional growth and a trend toward more stable habitats, the once man-disturbed habitats on Green Island are becoming

TABLE 5. Longevity and Status of the Plants that are New Records for Each of the Islands in 1969

Island	Lost Ballast	Little Chicken	Big Chicken	Starve	Hen	Gibraltar	Green
Percentage of the new records which are:*							
a) non-indigenous annuals	0 (0-2)	0 (0-0)	55 (6-11)	31 (11-36)	40 (14-35)	16 (5-31)	18 (3-17)
b) non-indigenous perennials	50 (1-2)	0 (0-0)	9 (1-11)	14 (5-36)	20 (7-35)	29 (9-31)	12 (2-17)
c) indigenous annuals	0 (0-2)	0 (0-0)	27 (3-11)	22 (8-36)	17 (6-35)	16 (5-31)	12 (2-17)
d) indigenous perennials	50 (1-2)	0 (0-0)	0 (0-11)	31 (11-36)	17 (6-35)	35 (11-31)	53 (9-17)

*The first number in parentheses is the number of new records in this category and the second is the total number of new records.

fewer, such that the establishment of non-indigenous annuals is apparently more difficult, but indigenous perennials are becoming re-established. Of the new records for Green Island since 1939, 3 of 17 species (18%) are non-indigenous annuals and 9 of 17 (53%) are indigenous perennials (Table 5).

The trends seen from the data for Gibraltar and Green Islands differ from those shown in the data for Hen Island. A gradual increase in the numbers of species, from 39 in 1903 to 68 in 1939 and to 80 in 1969 has occurred (Table 2). Since 1939, this increase is accounted for mostly by non-indigenous annuals (14 of 35 new records or 40%, Table 5). The changes in the flora on Hen Island are probably related to man's increased use of this rather remote island in the past thirty years.

CHANGES RELATED TO THE SIZE AND PHYSIOGRAPHY OF THE ISLANDS

The percentage of species new to any island (new records) is higher on the small gravel bar islands and lower on the larger islands. Big Chicken Island, one of the small gravel bar islands, has the highest percentage of new records (73%). Green Island, the largest island studied, has the lowest percentage of new records (13%). A comparison of island size and percentage of new records can be made from the information in Tables 1 and 2. This trend also correlates with the amount of disturbance on the islands. The habitats on the gravel bar islands are continually undergoing disturbance (particularly from wave erosion and ice action), whereas the habitats on the large islands are more stable. Because of the severe environmental influences and physiographic features (extreme small island size and slight elevation above the surface of the water), these correlations are not shown for Lost Ballast and Little Chicken Islands.

SUMMARY

Comparisons of the floras of seven small islands in western Lake Erie have shown that (1) 30-40% of the species on Starve, Hen, Gibraltar, and Green Islands; 68% of the species on Lost Ballast; 67% of the species on Big Chicken; and all of the species on Little Chicken Island have disappeared since 1939; (2) the percentage of annuals and non-indigenous species has increased and the percentage of perennials and indigenous species has decreased for most of the islands; (3) of the species that have invaded in the past 30 years, annuals have apparently been more successful in becoming established on the disturbed gravel bar islands, whereas perennials have been most successful in becoming established on the larger islands; and (4) the percentage of species new to any island is higher on the small gravel bar islands and lower on the larger islands. Some of the apparent reasons for these floristic changes are the influences of wave erosion, ice action, fluctuating water level, and bird inhabitation on the small gravel bar islands. Man's influence and general vegetation succession have been important factors in the floristic changes on the larger islands.

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TABLE 6. Location, Longevity, and Status of All Species Seen in 1903, 1939, and 1969 on Seven Small Islands in Western Lake Erie.*

Species	Longevity & Status**	Lost Ballast		Little Chicken			Big Chicken			Starve		Hen			Gibraltar		Green	
		39	69	03	39	69	03	39	69	39	69	03	39	69	39	69	39	69
(1) Species which have disappeared from all reported locations																		
Polypodium virginianum	P-I															x		
Agrostis alba	P-I				x								x					
Bromus racemosus	A-NI															x		
Bromus secalinus	A-NI															x		
Muhlenbergia mexicana	P-I																	x
Carex blanda	P-I												x					x
Carex frankii	P-I															x		
Carex sprengelii	P-I																	x
Scirpus fluviatilis	P-I							x										
Erythronium americanum	P-I																	x
Smilax ecirrata	P-I															x		x
Smilax herbacea	P-I																	x
Smilax hispida	P-I																	x
Dioscorea villosa	P-I																	x
Salix cordata	P-I																	x
Salix glaucophylloides	P-I												x					
Quercus acuminata	P-I											x						
Ulmus thomasii	P-I															x		x
Laportea canadensis	P-I																	x
Pilea pumila	A-I											x	x					
Comandra umbellata	P-I															x		
Polygonum pensylvanicum	A-I	x		x														
Polygonum punctatum	A or P-I	x																
Rumex orbiculatus	P-I				x					x						x		x
Rumex obtusifolius	P-NI												x					x

Chenopodium hybridum var. *gigantospermum*	A-I						
Claytonia virginica	P-I					x	
Cerastium nutans	A-I						x
Silene antirrhina	A-I					x	
Hepatica americana	P-I						x
Thalictrum dioicum	P-I						x
Podophyllum peltatum	P-I						x
Fumaria officinalis	A-NI						x
Arabis laevigata	B-I						x
Brassica kaber var. *pinnatifida*	A-NI				x		
Dentaria laciniata	P-I					x	
Descurainia pinnata var. *brachycarpa*	A or B-I						x
Rorippa islandica var. *hispida*	A or B-I			x		x	x
Sedum ternatum	P-I	x					
Potentilla norvegica	A or B-I					x	
Prunus persica	P-NI					x	
Rubus allegheniensis	P-I				x		
Rubus pensilvanicus	P-I				x		
Gleditsia triacanthos	P-I						x
						x	

*This table lists all of the species (taxa) seen in 1903 and reported by Kellerman (1904), seen in 1939, 1940, and 1941 and reported by Core (1948), and seen by us in 1967, 1968, and 1969. The year listed under the name of each island is the year when a majority of the field studies were conducted although the records are for three-year periods in the cases of those by Core and by us. The taxa are grouped according to those species which (1) have disappeared from all reported locations, (2) have disappeared from one or more but not all reported locations, (3) have disappeared from one or more reported locations, but in 1969 were seen for the first time at one or more *other* locations, (4) in 1969 were seen only at previously reported locations, (5) in 1969 were seen at all previously reported locations and for the first time at one or more other locations, and (6) in 1969 were seen for the first time at one or more locations. Nomenclature agrees primarily with Fernald (1950), although Gleason (1952) and Braun (1967) were consulted for the names of a few species. Data on longevity were determined from field study, from McDonald (1937), and for a few species from Muenscher (1949) and Fernald (1950). Data on the status of each species were taken from Kellerman and Kellerman (1900), Muenscher (1949), and Fernald (1950).

**A=Annual; B=Biennial; P=Perennial; I=Indigenous; NI=Non-indigenous.

TABLE 6 (Continued)

Species	Longevity & Status	Lost Ballast 39 69	Little Chicken 03 39 69	Big Chicken 03 39 69	Starve 39 69	Hen 03 39 69	Gibraltar 39 69	Green 39 69
Lathyrus palustris	P-I						x	
Medicago sativa	P-NI						x	
Melilotus officinalis	B-NI						x	
Vicia americana	P-I						x	
Euphorbia maculata	A-I						x	
Rhus aromatica	P-I						x	
Ilex verticillata	P-I							x
Euonymus atropurpureus	P-I							x
Oenothera biennis	B-I			x				
Ligustrum vulgare	P-NI						x	
Apocynum cannabinum	P-I				x			
Lithospermum arvense	A or B-NI						x	
Verbena hastata	P-I			x				x
Hedeoma pulegioides	A-I						x	
Lycopus virginicus	P-I							x
Marrubium vulgare	P-NI							x
Monarda fistulosa	P-I							x
Teucrium occidentale	P-I						x	
Campsis radicans	P-I					x		
Scrophularia marilandica	P-I							x
Cephalanthus occidentalis	P-I							x
Galium mollugo	P-NI						x	
Anthemis cotula	A-NI						x	
Taraxacum erythrospermum	P-NI					x		
Viola cucullata	P-I						x	x
Fraxinus nigra	P-I				x			

Convolvulus arvensis	P-NI													x				x			
Echinocystis lobata	A-I				x																
Eclipta alba	A-I		x																		
Solidago hispida	P-I																	x			
Solidago canadensis	P-I																	x			
Lactuca floridana	A-I																	x			
Erigeron strigosus	A-I															x		x			
(2) Species which have disappeared from one or more but not all reported locations																					
Elymus virginicus	P-I									x	x		x	x	x			x			
Panicum lanuginosum	P-I		x												x			x	x		
Carex brevior	P-I												x					x	x		
Juncus dudleyi	P-I		x							x	x		x	x				x	x		
Asparagus officinalis	P-NI												x		x	x					
Polygonatum canaliculatum	P-I												x					x	x		
Populus deltoides	P-I		x	x		x				x	x	x	x		x	x		x	x		
Populus tremuloides	P-I											x	x					x	x		
Salix alba	P-NI		x				x	x							x	x		x	x		
Salix amygdaloides	P-I		x	x		x	x			x	x				x			x			
Salix discolor	P-I												x		x			x	x		
Quercus muehlenbergii	P-I												x		x	x		x	x		
Quercus rubra var. *borealis*	P-I														x	x		x			
Celtis occidentalis	P-I		x	x		x	x		x		x	x		x	x	x		x	x		
Ulmus americana	P-I		x	x		x					x	x	x	x	x			x	x		
Ulmus rubra	P-I													x				x	x		
Morus rubra	P-I										x							x	x		
Urtica dioica var. *procera*	P-I								x					x	x			x	x		
Polygonum convolvulus	A-NI																	x	x		
Phytolacca americana	P-I											x		x	x			x	x		
Stellaria media	A-NI												x		x			x	x		
Ranunculus abortivus	P-I																	x	x		

TABLE 6 (Continued)

Species	Longevity & Status	Lost Ballast 39	69	Little Chicken 03	39	69	Big Chicken 03	39	69	Starve 39	69	Hen 03	39	69	Gibraltar 39	69	Green 39	69
Hepatica acutiloba	P-I														x		x	x
Menispermum canadense	P-I	x	x												x	x	x	
Arabis drummondii	B-I												x		x	x	x	x
Barbarea vulgaris var. *arcuata*	P-NI											x	x				x	x
Heuchera americana	P-I												x		x	x	x	x
Ribes cynosbati	P-I											x			x	x	x	x
Fragaria vesca var. *americana*	P-I														x		x	x
Prunus serotina	P-I														x	x	x	
Geranium robertianum	A or B-NI											x			x	x	x	x
Geranium carolinianum	A-I									x	x						x	
Rhus typhina	P-I	x								x	x	x	x	x	x	x	x	x
Celastrus scandens	P-I									x					x	x	x	x
Euonymus obovatus	P-I														x		x	x
Acer negundo	P-I						x	x							x	x		
Acer nigrum	P-I											x	x		x		x	x
Impatiens pallida	P-I											x	x				x	x
Parthenocissus quinquefolia	P-I	x								x		x	x	x	x	x	x	x
Tilia americana	P-I	x													x	x	x	x
Althaea rosea	P-NI												x	x			x	
Malva neglecta	A or B-NI												x	x			x	
Viola pubescens	P-I														x		x	x
Osmorhiza longistylis	P-I														x		x	x
Fraxinus americana	P-I	x	x							x					x	x	x	x
Asclepias syriaca	P-I				x					x			x	x	x	x	x	x
Convolvulus sepium	P-I												x	x	x	x	x	
Lycopus americana	P-I	x		x											x	x	x	x

Satureja vulgaris	P-I													x		x	x
Verbascum thapsus	P-NI	x								x	x	x	x	x	x	x	x
Galium aparine	A-I												x	x	x		
Sambucus canadensis	P-I	x				x		x	x	x	x	x	x	x	x	x	x
Sicyos angulatus	A-I			x	x	x	x			x					x	x	
Campanula americana	A or B-I									x					x	x	
Aster shortii	P-I									x	x	x	x	x	x		
Aster pilosus var. *pringlei*	P-I							x	x		x		x	x	x	x	
Erigeron annuus	A-I	x								x	x	x	x	x	x	x	
Erigeron philadelphicus	A-I	x						x	x				x	x	x	x	
Taraxacum officinale	P-NI	x		x				x	x		x	x	x	x	x	x	
Prenanthes alba	P-I												x		x	x	
Smilacina stellata	P-I							x		x	x	x	x		x	x	
Dactylis glomerata	P-NI									x	x	x	x	x	x		

(3) Species which have disappeared from one or more reported locations, but in 1969 were seen for the first time at one or more other locations

Andropogon gerardii	P-I													x			x
Panicum capillare	A-I	x								x							
Scirpus americanus	P-I			x						x							
Smilacina racemosa	P-I											x	x		x	x	
Salix interior	P-I	x								x					x	x	
Polygonum lapathifolium	A-NI		x	x		x		x	x					x	x		x
Rumex crispus	P-NI			x				x	x			x	x	x	x	x	
Atriplex patula	A-I		x						x								
Veronica arvensis	A-NI								x			x			x	x	
Chenopodium album	A-NI	x					x	x	x	x	x	x	x	x			x
Lepidium virginicum	A or B-I						x	x	x				x	x	x		
Rorippa islandica var. *fernaldiana*	A or B-I								x						x		
Sisymbrium officinale	A-NI									x	x	x		x	x		
Potentilla recta	P-NI												x			x	

TABLE 6 (Continued)

Species	Longevity & Status	Lost Ballast 39	Lost Ballast 69	Little Chicken 03	Little Chicken 39	Little Chicken 69	Big Chicken 03	Big Chicken 39	Big Chicken 69	Starve 39	Starve 69	Hen 03	Hen 39	Hen 69	Gibraltar 39	Gibraltar 69	Green 39	Green 69
Trifolium repens	P-NI													x	x	x	x	
Impatiens capensis	A-I			x												x	x	
Daucus carota	P-NI													x		x	x	
Fraxinus pennsylvanica	P-I	x									x	x	x		x	x	x	x
Lamium amplexicaule	A or B-NI													x	x	x	x	
Nepeta cataria	P-NI				x			x	x		x	x	x	x	x	x	x	x
Physalis heterophylla	P-I									x						x		
Ambrosia artemisiifolia	A-I			x	x				x		x		x		x	x		x
Bidens frondosa	A-I			x										x		x		
Cirsium vulgare	P-NI								x	x					x	x	x	x
Cirsium arvense	P-NI	x		x	x								x	x		x	x	x
Erechtites hieracifolia	A-I	x		x					x					x		x		
Erigeron canadensis	A-I	x		x	x		x			x	x			x		x	x	
Sonchus asper	A-NI								x					x	x		x	
Sonchus oleraceus	P-NI													x	x	x	x	
Lactuca scariola	A or B-NI	x			x		x	x	x	x	x			x	x	x	x	x
Capsella bursa-pastoris	A-NI						x	x		x	x	x	x	x	x	x	x	
Strophostyles helvola	A-I				x											x		
Polygonum persicaria	A-NI	x			x		x		x	x	x			x	x		x	
Rhus radicans	P-I	x								x			x	x	x	x	x	x
Bidens connata	A-I			x														x
(4) Species which in 1969 were seen only at previously reported locations																		
Taxus canadensis	P-I																x	x
Elymus canadensis	P-I									x	x				x	x		
Hystrix patula	P-I																x	x
Phleum pratense	P-NI														x	x	x	x

Poa pratensis	P-I									x	x	x	x	x	x		
Sphenopholis obtusata	P-I									x	x			x	x		
Carex cephalophora	P-I											x	x				
Carex eburnea	P-I											x	x	x	x		
Allium canadense	P-I											x	x				
Allium cernuum	P-I											x	x	x	x		
Allium tricoccum	P-I													x	x		
Camassia scilloides	P-I									x	x			x	x		
Hemerocallis fulva	P-NI									x	x						
Trillium flexipes	P-I													x	x		
Uvularia grandiflora	P-I													x	x		
Carya ovata	P-I											x	x				
Ostrya virginiana	P-I											x	x	x	x		
Humulus lupulus	P-I													x	x		
Cerastium arvense	P-I											x	x	x	x		
Dicentra cucullaria	P-I													x	x		
Thlaspi arvense	A-NI											x	x				
Sedum acre	P-NI											x	x				
Platanus occidentalis	P-I											x	x				
Amelanchier sanguinea	P-I											x	x				
Geum canadense	P-I										x		x	x	x	x	x
Prunus virginiana	P-I	x	x								x	x	x	x	x	x	x
Rosa carolina	P-I													x	x		
Gymnocladus dioica	P-I										x	x	x	x	x	x	x
Melilotus alba	B-NI								x	x				x	x	x	x
Robinia pseudo-acacia	P-I													x	x		
Trifolium pratense	P-NI													x	x		
Ailanthus altissima	P-NI															x	x
Euphorbia cyparissias	P-NI													x	x		
Ptelea trifoliata	P-I													x	x	x	x

TABLE 6 (Continued)

Species	Longevity & Status	Lost Ballast 39	69	Little Chicken 03	39	69	Big Chicken 03	39	69	Starve 39	69	Hen 03	39	69	Gibraltar 39	69	Green 39	69
Staphylea trifolia	P-I																x	x
Acer saccharum	P-I											x	x	x	x	x	x	x
Aesculus hippocastanum	P-NI	x	x															
Vitis riparia	P-I	x	x							x	x	x	x	x	x	x	x	x
Viola nephrophylla	P-I									x	x						x	x
Aralia nudicaulis	P-I																x	x
Sanicula canadensis	B or P-I																x	x
Cornus obliqua	P-I	x	x												x	x		
Lysimachia quadriflora	P-I																x	x
Fraxinus pennsylvanica var. *subintegerima*	P-I														x	x		
Syringa vulgaris	P-NI												x	x	x	x	x	x
Vinca minor	P-NI														x	x	x	x
Phlox divaricata	P-I																x	x
Hydrophyllum virginianum	P-I																x	x
Prunella vulgaris	P-NI														x	x	x	x
Teucrium canadense	P-I														x	x	x	x
Solanum nigrum	A-NI												x	x	x	x	x	x
Penstemon hirsutus	P-I											x	x	x	x	x	x	x
Phryma leptostachya	P-I																x	x
Plantago lanceolata	B or P-NI														x	x		
Lonicera dioica var. *glaucescens*	P-I														x	x	x	x
Lobelia kalmii	P-I																x	x
Antennaria plantaginifolia	P-I														x	x		
Chrysanthemum leucanthemum	P-NI														x	x		
Solidago flexicaulis	P-I																x	x

Solidago graminifolia	P-I					x	x	x	x	x					
Polymnia canadensis	P-I													x	x
Lapsana communis	A-NI											x	x		
Lactuca canadensis	A or B-I											x	x	x	x
Pellaea glabella	P-I											x	x		
Elymus villosus	P-I											x	x	x	x
Fraxinus quadrangulata	P-I								x	x		x	x	x	x
Polygonum scandens	P-I							x		x					

(5) Species which in 1969 were seen at all previously reported locations and for the first time at one or more other locations

Juniperus virginiana	P-I									x	x	x	x	x	
Agrostis hyemalis	P-I										x	x		x	
Poa compressa	P-NI						x		x	x	x	x	x	x	
Setaria glauca	A-NI						x			x	x	x	x	x	
Polygonatum pubescens	P-I									x	x	x	x	x	
Amaranthus retroflexus	A-NI			x		x	x			x					
Portulaca oleracea	A-NI			x			x			x	x	x	x	x	
Arenaria serpyllifolia	A-NI						x		x	x	x	x	x	x	
Cerastium vulgatum	B or P-NI											x	x	x	
Anemone virginiana	P-I											x	x	x	
Aquilegia canadensis	P-I						x				x	x	x	x	
Arabis shortii	B-NI									x			x	x	
Lepidium campestre	A or B-NI						x				x	x	x	x	
Rubus occidentalis	P-I											x	x	x	
Medicago lupulina	A-NI										x	x		x	
Oxalis europaea	P-I									x	x	x	x	x	
Geranium pusillum	A-NI						x				x	x			
Acalypha rhomboidea	P-I										x	x		x	
Euphorbia supina	A-I									x	x	x			
Cornus drummondii	P-I	x	x			x	x		x	x				x	

TABLE 6 (Continued)

Species	Longevity & Status	Lost Ballast 39	Lost Ballast 69	Little Chicken 03	Little Chicken 39	Little Chicken 69	Big Chicken 03	Big Chicken 39	Big Chicken 69	Starve 39	Starve 69	Hen 03	Hen 39	Hen 69	Gibraltar 39	Gibraltar 69	Green 39	Green 69
Leonurus cardiaca	P-NI										x				x	x	x	x
Solanum dulcamara	P-NI		x								x			x	x	x	x	x
Plantago rugelii	P-I										x				x	x		
Campanula rotundifolia	P-I									x	x			x	x	x	x	x
Arctium minus	B-NI								x				x	x	x	x	x	x
Achillea millefolium	P-NI											x	x	x		x	x	x
Juncus tenuis	P-I										x						x	x
Morus alba	P-NI	x	x								x				x	x	x	x
Parietaria pensylvanica	A-I													x	x	x	x	x
Polygonum aviculare	A-NI										x			x	x	x		
Physocarpus opulifolius	P-I										x				x	x	x	x
Hydrophyllum appendiculatum	B-I													x			x	x
(6) Species which in 1969 were seen for the first time at one or more locations																		
Onoclea sensibilis	P-I																	x
Digitaria sanguinalis	A-NI							x			x			x				
Eragrostis megastachya	A-NI										x							
Eragrostis pectinacea	A-I										x							
Cyperus ferruginescens	A-I														x			
Cyperus erythrorhizos	A-I										x							
Eleocharis erythropoda	A-I										x							
Commelina communis	A-NI														x			
Rumex altissimus	P-I														x			
Saponaria officinalis	P-NI													x				
Ranunculus sceleratus	A-I										x							
Alliaria officinalis	B-NI														x			

Sisymbrium altissimum	B-NI			x				
Sedum sarmentosum	P-NI				x	x		
Rosa multiflora	P-NI						x	
Rhus glabra	P-I						x	
Acer saccharinum	P-I	x		x				
Parthenocissus inserta	P-I					x		
Galium triflorum	P-I				x			
Galinsoga parviflora	A-NI				x	x		
Carex rosea	P-I						x	
Quercus alba	P-I					x		
Boehmeria cylindrica	P-I			x				
Arenaria stricta	P-I					x	x	
Cakile edentula	A-I					x		
Lychnis alba	B-NI						x	
Polanisia graveolens	A-I				x			
Antirrhinum majus	P-I					x		
Ambrosia trifida	A-I			x				
Echinochloa crusgalli	A-NI			x	x			
Arisaema atrorubens	P-I					x	x	
Trifolium procumbens	A-NI					x		
Vicia caroliniana	P-I					x		
Lycopus uniflorus	P-I					x		
Veronica peregrina	A-I					x		
Sonchus arvensis	A-NI		x		x	x		

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A REPORT ON THE 1969 MOREL SEASON IN MICHIGAN

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Approximately 250 people from scattered areas of the State of Michigan reported on their success (or lack of it) gathering morel mushrooms in the spring of 1969. A questionnaire was mailed to people who had at one time or another attended one of our mushroom workshops. Their reports and comment should help us prepare for morel seasons to come.

Respondents replied to the following questions:

1. Approximately how many morels did you harvest this year? 2. Which kinds were they? 3. Would you say this was a very poor, poor, average, or better than average year? 4. What were the approximate dates when picking was the best? 5. In what kind of territory do you find your best picking (tree cover, slope, exposure, etc.)?

The manner in which the volume of harvest was reported varied. Some people counted each fruiting body with the numbers varying from "one, only one" to over 2,000. Amounts were also indicated in meals, pounds, quarts, gallons, pecks, and bushels.

It was interesting to note that even though people in some areas reported a harvest of several bushels of morels they rated the season as very poor. This was particularly apparent in reports coming from the northern part of Lower Michigan. By comparison, a harvest of several bushels would be considered a very good season in most parts of the Upper Peninsula.

To the question, "What kinds were they?" answers varied: Such terminology as black morels, white morels, brown morels, closed-caps, open-caps,

loose-caps, beefsteaks, gray morels, early-capped, late gray, tan morels, open-stem or woods mushroom, sponge mushroom, early morel, late morel, light beige morel, large light morel, sandy sponge morel, cone-type morel, grayish brown morel, large cinnamon morel, pine tree morel, and elephant ears. One could only guess at the species when tabulating results.

Some respondents used scientific names, particularly in the Traverse City and Sault Ste. Marie areas. They listed *Morchella angusticeps, Morchella esculenta, Morchella crassipes, Morchella hybrida, Verpa bohemica, Helvella esculenta, Helvella gigas,* and *Morchella deliciosa.* This added materially to the value of their information.

The species distribution in the state made an interesting study. In the Upper Peninsula the predominant species harvested is *Morchella angusticeps* (black morel), but a substantial volume of *Helvella esculenta* is harvested and eaten. *Verpa bohemica* is prolific in the U. P. and *Helvella gigas* is reportedly collected there in volume. Very few reported harvest of *Morchella esculenta* (white morel) in the U. P., though we know they do grow in the area because of a few reported large-volume harvests.

In the northern half of the Lower Peninsula, *Morchella esculenta* (white morel) is the predominant species. *Morchella angusticeps* contributes some volume to the harvest. *Verpa bohemica* (often reported as the loose or open-cap morel) is harvested in abundance as is *Helvella esculenta.* There are some reports of *Morchella crassipes* being harvested also.

In the southern half of the state, *Morchella esculenta* and *Morchella crassipes* were the predominant species in the reported harvest. Very few reported any volume of *Morchella angusticeps.*

When asked to evaluate the season, the respondents were practically unanimous in the rating for their area.

In the U. P., the season for *Morchella* species was rated poor to very, very poor. The season for *Verpa bohemica* was better than average. I saw one four-bushel harvest of *Verpa bohemica* picked near Marquette in a two-day period and which was being transported to Ohio for consumption. Three people indicated that *Verpa bohemica* made them ill. Those who pick *Helvella esculenta* reported an average to good season.

In the northern half of the Lower Peninsula, respondents rated the season as average and above average for *Morchella esculenta* and very poor for *Morchella angusticeps.* A heavy fruiting of *Verpa bohemica* was reported also.

In the southern half of the Lower Peninsula, respondents to this survey reported a very poor to average season. *Morchella esculenta* and *Morchella crassipes* were the dominant species. The poor season seemed to be attributed to competition among collectors as much as to the actual fruiting.

Most interesting was the reported time of optimum harvest for the 1969 season. In the entire state, best picking was between the second week and the end of May. Apparently the species most abundantly harvested (*Morchella crassipes* in the southern part of the state, *Morchella esculenta* in the northern half of the Lower Peninsula, and *Morchella angusticeps* in the Upper Peninsula) all fruit at approximately the same time. We know if we were limited to

any one area we would look first for *Helvella gigas, Verpa bohemica,* and *Helvella esculenta,* followed by *Morchella angusticeps,* then *Morchella esculenta,* and last *Morchella crassipes.*

As would be expected in a survey of the entire state, there were reported collections in late April to mid June. Generally, the weather was blamed for the poor season. "Too cold" in all areas and "too dry and too cold" in some southern and most northern areas. Answers to "In what kind of territory did you find your best picking?" were naturally general in nature. No one will lead you to his patch.

In the southern half of the Lower Peninsula, harvesting was best in rich river-bottom land, ash stands, old orchards, hedge rows, and on wooded slopes and ridges. Dead or dying elms were indicated present in almost all of the best areas. (*Morchella esculenta* and *Morchella crassipes* were the main species harvested.)

The terrain varied in the northern half of the Lower Peninsula where the harvest included *Verpa bohemica, Helvella esculenta, Morchella esculenta,* and a few *Morchella crassipes.* Best collecting areas indicated for *Morchella angusticeps* were wooded slopes, black cherry stands, borders of marshes and orchards. *Morchella esculenta* and *Morchella crassipes* were harvested from elm slashings, grassy fields, high areas and ridges of wooded slopes with sandy soil, north facing slopes covered with mixed, sparse, young tree cover and orchards. *Helvella esculenta* was harvested from conifer plantations.

In the U. P., where most of the harvest is *Morchella angusticeps,* areas for best picking included wooded slopes and ridges of young mixed tree growth, aspen slashings (1-, 2-, and 3-year old), berry bramble, fern-filled fields, old orchards, slashings next to swamps, old pastures, aspen groves, and along logging roads. Several collectors reported good harvest in Norway Pine plantations as late as June 15. Mushrooms are easily spotted in a bed of pine needles. Perhaps we stop looking too soon.

Some scattered reports of good collecting for *Morchella esculenta* (white morel) came from areas in the U. P. adjacent to Lakes Michigan and Huron. A few came from inland areas and an occasional one from areas near the Lake Superior shore. The types of areas included elm thinnings, along ditches and right-of-way of gravel roads, and in stands of elm and ash. *Verpa bohemica* was collected in quantity on aspen and hardwood covered slopes and along borders of swamps. *Helvella esculenta* was collected mostly in evergreen tree cover. predominantly pines.

CONDENSATION OF MOREL HARVEST REPORTS, 1969 SEASON, BY AREAS

Species interpretation used by tabulator:

Morchella angusticeps - included those termed blacks, pine-cones, cone-mushroom.
Morchella esculenta - whites.
Verpa bohemica - loose-caps, open-caps.
Helvella esculenta - beefsteaks.

Southwest Lower Michigan (reports from Niles and Sherwood vicinities):

Very poor season–dry cold weather–best picking between May 11 and May 30–*Morchella angusticeps, Morchella esculenta,* and *Morchella crassipes* found near cherry and elms, on partially wooded slopes and river bottoms.

Southeast Lower Michigan (reports from Ann Arbor, Fenton, Flint, Holly, Lambertville, and Davison):

Season rated very poor to good–best picking during last two weeks of May–*Morchella esculenta* and *Morchella crassipes* collected near elms, in hedge rows, along river banks, on wooded slopes, among landscape plantings–some *Morchella angusticeps* found on ash and aspen covered slopes.

Central West Side of Lower Michigan (reports from Baldwin, Bitely, Onekama, Irons, Manistee, Reed City, Scottsville, Branch, Evart, Luther, Tustin, Ludington, and Cadillac):

Season reported to be "worst in 20 years"–poor to very poor by two-thirds of respondents, average by one-third–too cold and dry–better for whites than blacks–*Morchella angusticeps, Morchella esculenta,* and *Helvella esculenta* collected from last week in April through May with best picking last two weeks of May–collections made on wooded slopes (hardwood and aspen cover), near dead or dying elms (for *Morchella esculenta*), orchards, and open woods.

Northwest Lower Lower Michigan (reports from Frankfort, Northport, Maple City, Traverse City, Gaylord, Williamsburg, Omena, Empire, and Mayfield):

Season rated as very poor to poor for *Morchella angusticeps* (unanimous) and average to better than average for *Morchella esculenta*–harvest began as early as May 1 and extended to June 9 with best picking May 10-25, peaking on May 16–*Morchella angusticeps* collected on wooded slopes, near base of hills, orchards, marsh borders, in black cherry–*Morchella esculenta* (as much as 5 bushels) collected from elm slashings, grassy fields, high areas on wooded sandy slopes, and near basswood.

Eastern Upper Peninsula, etc. (reports from Goetzville, Paradise, Cedarville, Pickford, Hessel, Hill Island, Pickford, St. Ignace, Sault Ste. Marie (Michigan & Ontario), Echo Bay (Ontario), Engadine, Naubinway, Newberry, and McMillan):

Season rated as very poor for all species except *Verpa bohemica* and *Helvella esculenta*–good to better than average for *Verpa bohemica, Helvella gigas,* and *Helvella esculenta–Morchella angusticeps* collected among tree cover (mixed aspen, beech and maple), old orchards, along edges of woods roads, open areas on high ground (those on lower ground froze), along ridges of small second growth hardwood and among adder's tongue and violets. A few *Morchella esculenta* were harvested in ditch and along right-of-way of gravel roads–*Helvella esculenta* collected in pines and under evergreens along Lakes Huron and Michigan shores. Collecting extended from last of April till June 3 with second week in May reported best.

Central and Southern Upper Peninsula (reports from Manistique, Escanaba, Caspian, Iron Mountain, Gladstone, Cornell, Bark River, Rapid River, Schaffer, Ishpeming, Marquette, Negaunee, North Lake, Gwinn, Republic, Munising, Wetmore, and AuTrain):

The season was unanimously rated very, very poor to poor because of the cold dry weather–*Morchella angusticeps* predominant species collected–average to better than average year for *Verpa bohemica*–rare reports of *Morchella esculenta*–collecting best during second and third week of May–found in aspen slashings, mixed tree cover (aspen, pine, balsam, and maple), slashings next to swamps, sunny wooded slopes, under small evergreens, aspen groves (frozen in all the exposed areas). Two unusual dates were reported: On June 15, substantial quantities of *Morchella angusticeps* were collected from a 25-year old Norway Pine plantation. At the end of October 1968, *Morchella angusticeps* was gathered from along a river bank.

North and Western Upper Peninsula (reports from L'Anse, Skanee, Chassell, Atlantic Mine, Houghton, Winona, Baraga, Ontonagon, Bruce Crossing, Ironwood, and White Pine):

A very poor season for *Morchella angusticeps*–better for *Helvella gigas, Helvella*

esculenta, and *Verpa bohemica*–best collecting during last two weeks of May with 15 and 16 rated best days–found in old pastures, along fence rows next to woods, among ferns in old fields, aspen groves, ridges, and slopes in young mixed hardwood, aspen, conifer stands.

SELECTED COMMENTS FROM RESPONDENTS

Almost everyone wanted more help in learning how to identify, collect, prepare, and preserve other mushrooms, edible greens, berries, cherries, nuts, roots, etc. Respondents wanted to learn about poisonous as well as edible plants. Many shared experiences, advice, and concerns.

"The whole mushroom family interests me, yet I am frightened each year at the number of people who pick them without really knowing much about them."

"Why not encourage more people to harvest and preserve *Armillaria mellea* and *Naematoloma* in autumn? We have about three years out of five when these 'stump mushroom' species could be harvested by the ton. They are good-flavored, easily clearned in large quantities if picked clean with a knife, easily canned. They are picked in large quantities by a few people; more should know about them. Couldn't these mushrooms be glamorized some way? Many of my 'shaggy-mane' picking friends don't know about these other species." Many asked "when to collect" with clues given in the news and on the radio.

Several resented spraying. "Stop spraying with DDT. Wild land does not need it."

"No doubt, it's beyond your scope, but the indiscriminate spraying with herbicide by the . . . Electric Association hurts any conservation efforts. I stress the word indiscriminate–like spraying by our gate of an area where *no* tree branches touched the high line, but it was there that the rare and protected Nodding Trillium grew. I haven't had the heart to look because I know the spray got to the trilliums. So needless–such spraying. In heavy growth of seedling maples I can understand the spraying, but not in open areas. I haven't looked in another open area where arbutus thrives, but I'll wager it was sprayed. Yes, we need electricity and help for 'brushing out' is scarce these years, but spraying an open area seems senseless."

A need for maps and rules was expressed. "I have been wondering if there are maps of the woods. There are many trails which twist and turn." "Rules of harvesting, such as what can be dug up and transplanted, are needed."

From Iowa: "There is *active* mushrooming in Iowa. Many, many people collect here; morels are available in the supermarkets from local collectors at 80 cents per half pound."

"I have broken morels and scattered them where I think they would grow (for 33 years) and they do grow there where I planted them in approximately 80 per cent of the places. I usually pick an area where the humus is rich and rotting and rotted wood is about, plus rotted poplar leaves."

"I pick mushrooms more for the enjoyment of being in the woods and out to find them. Last fall a friend and I picked eight bushels of the stump mushrooms. We did this in about two and one-half hours. We left many behind in the small area we found them in; it was great picking."

"Morels appear about the time the ground brush is starting to leaf out and popple trees are beginning to green, providing proper amount of rain makes soggy walking on dead leaves. When ferns and ground cover start vigorous growth, morels are finished."

"Have the mushroom sellers pay a tax as the byuers. It's getting to be quite a racket. Seems to be less mushrooms every year and more pickers. It seems the people who take them out of state should have to pay a license. Every time anything is free they come up."

MICHIGAN PLANTS IN PRINT

New Literature Relating to Michigan Botany

A. MAPS, SOILS, GEOGRAPHY, GEOLOGY

The following topographic maps for Michigan have been published by the U. S. Geological Survey, 1200 S. Eads St., Arlington, Virginia 22202, since the previous listing in our January 1969 issue. All are 7½-minute quadrangles (scale of 1:24,000 or about 2½ inches to a mile). Maps are supplied with green overprint showing wooded areas unless request is made to the contrary, and are $.50 each, with a 20% discount on orders totalling $20.00 or more. Revised maps are marked with an asterisk in the list below; others are new or resurveyed. Following the name of the quadrangle, the county or counties in which it primarily lies are added.

Bay City [Bay, Saginaw]
Bay City NE [Bay]
Berkey* [Lenawee, plus Ohio]
Brich Run N. [Saginaw]
Bridgewater [Washtenaw]
Butternut [Montcalm]
Caledonia [Kent]
Carleton* [Monroe, Wayne]
Carson City [Gratiot, Montcalm]
Cedar Springs [Kent]
Cedar Springs SW [Kent]
Crump [Bay]
Cutlerville [Kent]
Erie* [Monroe]
Essexville [Bay]
Estral Beach* [Monroe]
Flat Rock* [Monroe, Wayne]
Flat Rock NE* [Wayne; formerly Detroit–Wayne Airport]
Grand Rapids E [Kent]
Grand Rapids W [Kent]
Hubbardston [Clinton, Ionia]
Kalamazoo [Kalamazoo]
Kalamazoo NE [Kalamazoo, Allegan]
Kalamazoo SW [Kalamazoo]
Kawkawlin [Bay]
Maybee [Monroe, Washtenaw, Wayne]
Monroe* [Monroe]
Mt. Forest [Bay, Arenac]
Otsego [Kalamazoo, Allegan]
Palo [Ionia]
Pinconning [Bay]
Portage [Kalamazoo]
Rockford [Kent]
Rockwood* [Wayne, Monroe]
Saginaw [Saginaw]
Saginaw NE [Saginaw]
Schoolcraft [Kalamazoo, St. Joseph]
Schoolcraft NW [Kalamazoo]
Sparta [Kent]
Standish [Arenac, Bay]
Standish NE [Arenac]
Tecumseh N [Lenawee, Washtenaw]
Vicksburg [Kalamazoo, St. Joseph]
Ypsilanti W [Washtenaw]

B. BOOKS, BULLETINS, SEPARATE PUBLICATIONS

Arend, John L., & Harold F. Scholz. 1969. Oak Forests of the Lake States and their Management. North Central For. Exp. Sta., U. S. For. Serv. Res. Pap. NC-31. 36 pp. [Includes data on oak stands in Michigan].

Kapp, Ronald O. 1969. How to Know Pollen and Spores. Wm. C. Brown, Dubuque. 249 pp. $3.25 (spiral), $4.00 (cloth). [Many of the 499 figures are drawn from Michigan material. See review on p. 165 of this issue.]

Shetron, Stephen G. 1969. Variation in Jack Pine Growth by Individual Soil Taxonomic Units in Baraga County, Michigan. Res. Notes Mich. Tech. Univ. Ford Forestry Center 5. 25 pp. (processed).

Smith, Bruce D., ed. 1969. Summer Science Journal. Vol. 1. Summer Science, Inc., Ann Arbor. 68 pp. [Contains reports on the geology, botany, aquatic biology, and archaeology projects of the 32 students (13-18 age group) enrolled during the summer of 1968 at Summer Science Camp, on 2200-acre Summer Island, off the tip of Michigan's Garden Peninsula (Delta Co.). While the reports, especially the orthography of scientific names, reveal the inexperience of their youthful authors, valuable data on the island are here recorded.]

Swink, Floyd. 1969. Plants of the Chicago Region. Morton Arboretum, Lisle, Illinois. 445 pp. $8.50 [Berrien Co., Michigan, is one of the 22 counties included in this checklist with extensive ecological notes. See review on p. 165 of this issue.]

C. JOURNAL ARTICLES

Bigelow, Howard E., & Margaret E. Barr. 1969. Contribution to the fungus flora of northeastern North America. V. Rhodora 71: 177-203. [Cites type of *Tricholomopsis bella* from Emmet Co.]

Bigelow, Howard E., & Alexander H. Smith. 1969. The status of Lepista—a new section of Clitocybe. Brittonia 21: 144-177. [Material of 11 species is cited from Michigan (usually with no further locality data) and a paratype of *C. irina* var. *luteospora.*]

Bonnot, E.-J. 1967. Ambrosia artemisiifolia L. Bull. Mens. Soc. Linn. Lyon 36: 348-359. [A general survey (in French) of knowledge about common ragweed, with references to some of the work done in Michigan, including a long footnote summarizing the thesis of Gebben on ecology of the species in southeastern Michigan.]

Byer, Michael D. 1969. The role of physical environment in some tracheophyte distributions along a soil moisture gradient. Bull. Torrey Bot. Club 96: 191-201. [Study area was in Crawford Co.]

Canham, Susan Carey. 1969. Taxonomy and morphology of Hypocrea citrina. Mycologia 61: 315-331. [Var. *citrina* cited from Tahquamenon Falls.]

Culberson, Chicita F. 1969. Chemical studies in the genus Lobaria and the occurrence of a new tridepside, 4-0 methylgyrophoric acid. Bryologist 72: 19-27. [Some of the herbarium material analyzed for certain of the taxa in this lichen genus was from Michigan.]

Review

GEOLOGY OF MICHIGAN. By John A. Dorr, Jr., & Donald F. Eschman. University of Michigan Press, 1970. 476 pp. $15.00.

Get this book! Any further review is only commentary on that three-word summary. Get it for its abundant handsome illustrations, well displayed on a large page size. (Figure legends not only cite localities where photographs were taken but also indicate them on an outline map of Michigan.) Get it for its charts and maps, its lists of collecting sites for minerals and fossils. Get it for information on Michigan's economic resources: iron, copper, salt, limestone, gas, petroleum, etc. Get it for fundamental explanations of the State's scenic features: sand dunes and waterfalls, the picturesque harbors of Keweenaw County, the Pictured Rocks, Mackinac Island's terraces and fort sites. Get it for the amply illustrated accounts of Michigan fossils: invertebrates, vertebrates (including man), and plants, the latter including billion-year-old algae in Ontonagon County—the oldest evidence of photosynthesis. Get it for the chapter on "Water and Wind in Michigan," which will be of particular interest to botanists (although the brief comments on the role of vegetation in filling of lakes fail to distinguish the unique features of bogs and swamps). Get it for the history of the Great Lakes, with maps and summary chart of outlets and dates.

Satisfyingly broad and complete in its scope, this volume will be a joy to anyone in this region who is curious about the land he lives on and the lakes which surround him and how they came into their present form. The text is written at a level from which an intelligent layman can learn much, and there are references to key literature. The only complaint about this oft-delayed production is the paper-covered boards used in binding; they do not look resistant to abrasion from the sands of Michigan or the dirty hands of field-trippers!

—E. G. V.

Program Notes

May 29-31: Michigan Botanical Club, Annual Spring Campout, at the University of Michigan Biological Station on Douglas Lake. A full program of field trips is planned; members are receiving complete information on reservations.

June 28: Southeastern Chapter, Annual Meeting, at the Drayton Plains Nature Center.

September 25-27: Southeastern Chapter, Fall Campout, at Yankee Springs.

Editorial Notes

Authors of articles in recent issues who wish to have manuscripts and/or art work returned should advise the eidtor immediately, before another "housecleaning" of his files.

The October issue will include a cumulative three-year index to volumes 7-9. It is contemplated that future volumes will include an annual index.

Prospective authors are urged to read "Information for Authors" on p. 62 of the January number.

The March number (Vol. 9, No. 2) was mailed March 17, 1970.

Publications of Interest

A GUIDE TO THE FLORA OF ELGIN COUNTY ONTARIO. By William G. Stewart and Lorne E. James. Catfish Creek Conservation Authority [1129 Talbot St., St. Thomas, Ontario], 1970 ["1969"]. 118 pp. $1.50 + $.25 postage. This is an annotated list of vascular plants and some bryophytes of a 720-square-mile county on the north shore of Lake Erie, with maps and background information. The list is not based on published reports, but only on species actually seen by the authors; voucher specimens for almost all are at the University of Western Ontario.

FOOD FOR US ALL. The Yearbook of Agriculture 1969. 360 pp. Another volume in the annual series, this one devoted to food: meat cuts, grading of foods, packaging, recipes, nutritive values, storage, shopping economy, etc. Available for $3.50 from the Superintendent of Documents (Washington 20402) or without charge fron one's congressmen.

CHROMOSOME NUMBERS OF FLOWERING PLANTS. By Z. Bolkhovskikh, V. Grif, T. Matvejeva, & O. Zakharyeva. An A. Federov (editor). V. L. Komarov Botanical Institute, Academy of Sciences of the USSR, Leningrad, 1969. 926 pp. 6R.92K. A vast index to 80 years' investigations throughout the world on plant chromosomes, indicating the numbers reported for 35,000 names of species, including many here newly listed. Since the preface appears in both Russian and English and the rest of the tome consists of scientific names and citations to the bibliography of 7,000 titles, this impressive compilation presents no language barrier. Families, genera, and species are arranged alphabetically; for genera containing over 10 species, tables summarize the distribution of chromosome numbers. Soviet botanists have rendered an invaluable service to Angiosperm systematists!

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THE MICHIGAN BOTANIST

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Articles and notes dealing with any phase of botany relating to the Upper Great Lakes Region may be sent to the editor in chief. The attention of authors preparing manuscripts is called to "Information for Authors" (Vol. 9, p. 62; copies available from the editor).

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Membership in the Michigan Botanical Club is open to anyone interested in its aims: conservation of all native plants; education of the public to appreciate and preserve plant life; sponsorship of research and publication on the plant life of the State; sponsorship of legislation to promote the preservation of Michigan native flora and to establish suitable sanctuaries and natural areas; and cooperation in programs concerned with the wise use and conservation of all natural resources and scenic features.

Dues are modest, but vary slightly among the chapters and with different classes of membership. Persons desiring to become state members (not affiliated with a local chapter) may send $3.00 dues to the Membership Chairman listed below. In all cases, dues include subscription to THE MICHIGAN BOTANIST. (Persons and institutions desiring to subscribe without becoming members should deal with the business and circulation manager as stated at the top of this page.)

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MYXOMYCETES FROM CHEBOYGAN AND EMMET COUNTIES, MICHIGAN

Laura S. Bradford
Department of Biology,
Washington University, St. Louis, Missouri

The Myxomycetes listed below were collected by the author during early July 1969 in the vicinity of the University of Michigan Biological Station. The first weeks of July had favorable conditions for plasmodial formation. June had been cold and very wet. During the first part of July, the weather became warmer and drier but due to the heavy rains in June the ground remained moist for several weeks. During these several weeks there were plentiful plasmodia and also freshly formed fruit-bodies of Myxomycetes.

Although this was not an intensive collecting program, two of the species listed below (*Lindbladia tubulina* and *Physarum confertum*) were not included in the preliminary survey for this area done by Brooks and Kowalski (1963) although they have been reported from Michigan elsewhere (Kauffman, 1910 & 1929; Gilman, 1943). Brooks and Kowalski (1963) had records of *Arcyria denudata, Reticularia lycoperdon,* and *Lycogala epidendrum* from Emmet County but not from Cheboygan County. All 12 genera and 14 species reported here were from Cheboygan County except the single collection of *Diachea leucopodia* which came from a hardwood forest in Emmet County. The two collections of *Stemonitis axifera* and the one collection of *Reticularia lycoperdon* came from a hardwood forest area near Mackinaw City. The other Cheboygan County collections came from forested areas between and adjacent to Douglas Lake and Burt Lake. The classification used is that of Martin and Alexopoulos (1969).

CERATIOMYXALES

Ceratiomyxaceae

1. *Ceratiomyxa fructiculosa* (Mull.) Macbr. – two collections, one on moss and one on bark.

LICEALES

Reticulariaceae

2. *Lycogala epidendrum* (L.) Fries – two collections, one on mossy log and the other on rotting wood.
3. *Reticularia lycoperdon* Bull. – one collection, on fallen log. Although many of the spores are free as in the description given in Martin and Alexopoulos (1969), spore clusters do exist mostly around the pseudocapillitium.
4. *Tubifera ferruginosa* (Batsch) Gmel. – one collection, on mossy log.

Cribariaceae

5. *Lindbladia tubulina* Fries – one collection, on fallen leaves and other forest floor debris.

TRICHIALES

Trichiaceae

6. *Arcyria denudata* (L.) Wettst. – two collections, both on old logs.
7. *Arcyria nutans* (Bull.) Grev. – one collection, on birch bark.

STEMONITALES

Stemonitaceae

8. *Stemonitis axifera* (Bull.) Macbr. – two collections, both on old logs.
9. *Diachea leucopodia* (Bull.) Rost. – one collection, on twig.

PHYSARALES

Physaraceae

10. *Fuligo septica* (L.) Weber – four collections, on rotting log, a leaf, a twig, and on bark.
11. *Physarum confertum* Macbr. – one collection, on moss, which Martin and Alexopoulos (1969) report as its favorite substrate.
12. *Physarum psittacinum* Ditm. – one collection, on dead wood. Martin and Alexopoulos (1969) report this as an "uncommon" species but Brooks and Kowalski (1963) have also reported two additional specimens of this particular species from this same area.

Didymiaceae

13. *Diderma spumarioides* (Fries) Fries – five collections, four of which were on leaves, the other on a twig.
14. *Mucilago crustacea* Wiggers – two collections, one on a dead leaf, the other on a twig.

ACKNOWLEDGMENTS

I wish to thank Dr. James Maniotis for his assistance in confirming the identification of the Myxomycetes listed in the study. Grateful acknowledgment is made to the National Science Foundation and the University of Michigan Biological Station for research funds provided under grant GB-8440.

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BOTANICAL RESULTS OF THE MICHIGAN GEOLOGICAL SURVEY UNDER THE DIRECTION OF DOUGLASS HOUGHTON, 1837-1840

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INTRODUCTION

The authors of the pioneer floras of North America, writing in the early 19th Century, knew little of Michigan, and their works contain few references to the plants of that state. Although such botanical celebrities as Thomas Nuttall (in 1810), David B. Douglass (in 1820), Edwin James (from 1827 to 1832), and Douglass Houghton (in 1831 and 1832), had visited Michigan and collected plants there, their collections were made under difficulties (and as a result were never very large), and the publications based on the collections were scattered and often brief. For the most part these early explorers traveled by water, and their botanizing was almost entirely restricted to the shores of the upper Great Lakes.

Even the first volume of the authoritative and comprehensive *Flora of North America* by John Torrey and Asa Gray, which was published in parts in 1838 and 1840, contains very few references to Michigan plants, although it was intended to cover the continent north of Mexico. It is thus of considerable interest to find that in the *North American Botany* by Eaton and Wright,[1] published in Troy, New York, in 1840, more than 1000 species of vascular plants were reported from Michigan, including many woodland and prairie species in addition to those from the shores of the Great Lakes. The *North American Botany* was essentially an eighth and revised edition of Amos Eaton's *Manual of Botany for North America,* of which the seventh edition had appeared in 1836. As the Michigan records were not included in the 1836 edition, it may be guessed that there is an interesting story behind their insertion *en masse* in the 1840 edition. A clue to the story may be found in the advertisement for the latter work, as quoted by Eaton in the preface (p. vi):

> "Age, and declining vision, have admonished the author that he must call in the aid of youthful zeal, with talented energies, to supply his loss by the waning of years. He has been so fortunate as to succeed in associating Dr. JOHN WRIGHT with him in this edition. He is a very zealous and accurate young naturalist. After some years of ardent devotedness to the Natural Sciences at this institution [the Rensselaer Institute at Troy], he had the benefit of Professors Ives' and Silliman's instructions at Yale College. He has since been united with Prof. Hall in the descriptive catalogue of Troy Plants. In the summer of 1838 he collected and

[1]Amos Eaton and John Wright. North American Botany; comprising the native and common cultivated plants, north of Mexico: Genera arranged according to the artificial and natural methods. 8th edition [of Eaton's *Manual of Botany*]. viii + 625 pp. Elias Gates, Troy, N. Y. 1840.

> reported, the plants of Michigan, as official Botanist to the State Geological Commission."
>
> "Dr. Wright is now going through all the generic and specific descriptions; correcting and modernizing the language, as far as may be done, without departing from the original simplicity of manner, peculiar to this work. New, and well authenticated discoveries, are also added by him. He has before him the works of Lindley, Torrey, Darlington, Hooker, Beck, &c. The contributions of many friends, in catalogues, letters, and rare plants, afford him many facilities."

A little further on (p. 16) Eaton added what he called a "remark": "The districts about our N.W. Lakes . . . have been in a great measure deficient in recorded localities of plants . . . the botanical surveys of Dr. Houghton, Dr. Wright, and his diligent assistant Mr. G. Bull, have supplied these deficiencies."

It seems clear from the above that the addition of the Michigan records ("new, and well authenticated discoveries") to the 1840 edition was primarily the work of Wright, and it may be surmised that the original source of many of the records is to be sought in Wright's work as "Botanist to the State Geological Commission." This is a little-known chapter in botanical history that deserves a fuller treatment.

In 1840 Michigan was a new and relatively poor State, having been admitted to the Union only 3 years before. It is remarkable that such a pioneer community was able to initiate a program which by 1840 made Michigan one of the better known states, botanically speaking, in the whole area west of the Alleghenies. In fact the botanical program comprised only a minor part of the Geological Survey of Michigan.

One of the early acts of the new State Legislature was to provide (February 23, 1837) for "an accurate and complete geological survey of the state." The survey was intended to result in a "full and scientific description of its rocks, soils & minerals & of its botanical and geological productions, together with specimens of the same." The governor was authorized to appoint a geologist to take charge of the Survey, and also to appoint some competent persons to act as assistants under the direction of the geologist.[2]

The moving spirit in the Geological Survey was a remarkable young man, Douglass Houghton (1809-1845), a native of New York who had studied with Professor Amos Eaton at the Rensselaer Institute in Troy. Houghton came to Detroit in 1830, upon Eaton's recommendation, to give a series of lectures on chemistry and other natural sciences. He spent the winter of 1830-31 in the city, before accepting the summer post of surgeon and botanist to the Schoolcraft Expedition to the sources of the Mississippi River. He returned from the expedition in October. The following summer he took a similar part in the second Schoolcraft Expedition, which in fact reached Lake Itasca. An account of Houghton's botanical work on the 1832 expedition appeared in 1962 in this journal.[3]

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[2]Acts of the Legislature of the State of Michigan 1837: 14. 1837.

[3]Janice L. Rittenhouse and Edward G. Voss. Douglass Houghton's botanical collections in Michigan, Wisconsin, and Minnesota on the Schoolcraft Expedition of 1832. Mich. Bot. 1: 61-70. 1962.

After Houghton's return from the expedition of 1832, he settled permanently in Detroit. He went into the practice of medicine, and by all accounts was successful. He speculated in Detroit real estate so profitably that all his biographers agree he became financially independent. He maintained at the same time his interest in the sciences, and he seems to have been almost solely responsible for the planning of the Michigan Geological Survey, and for the adoption of the project by the Legislature. The first Governor of Michigan, Stevens T. Mason, close upon the legislative action authorizing the Survey, appointed Houghton to the post of State Geologist.[4]

In order to understand and appreciate the botanical work of the Geological Survey, we should digress briefly to describe the conditions in Detroit and in Michigan at that time. Although forts and settlements on the shores of the upper Great Lakes had been in existence for almost 200 years, the interior of northern Michigan was a wilderness; in fact there were few settlements north of Saginaw Bay except on the lake shores. The population of Detroit in 1830 was 2222; by 1840 it had risen to 9102. Increase Lapham, who later became known as a competent amateur botanist in Wisconsin, visited Houghton in June, 1836, when a geological survey "was being talked of." Lapham described Detroit as "a fine city one hundred and thirty-five years old; it contains about 8,000 inhabitants, several fine four-story brick buildings, numerous fine churches and a market-house as large as an ordinary Presbyterian church and built much in the same style!"

At this same time, according to Lapham, Grand Haven, Michigan, was a new town of ten houses and one steam mill; Milwaukee, Wisconsin, consisted of 50 houses, and claimed a thousand inhabitants including the suburbs.[5]

Travel by road in Michigan was limited to the southern tiers of counties. When Houghton and his assistant, Bela Hubbard, set out on the first geological excursion in September, 1837, they travelled by wagon the first day from Detroit to Royal Oak, where they camped by the roadside. The following day they continued by wagon as far as Byron (then consisting of a mill and two houses) in southeastern Shiawassee County, whence they were obliged to continue their journey to Saginaw Bay by canoe. Midland was a "village without inhabitants"; in the Saginaw Valley the travelers found they had "penetrated into the wilderness, many miles beyond the most remote of the settlements of the Anglo-Saxon. Wild game was very abundant. . . . Besides deer, we had often seen along the shore, tracks of the elk, and sometimes of the moose. . . ."[6]

Earlier the same year, when Houghton was exploring farther west in the Lower Peninsula, he went from Detroit to Ann Arbor and Jackson by road,

---

[4]Bela Hubbard. A memoir of Dr. Douglass Houghton. Am. Jour. Sci. II. 5: 217-227. 1848. Alvah Bradish. Memoir of Douglass Houghton. xii + 302 pp. + frontisp. Raynor & Taylor, Detroit, 1889. Edsel K. Rintala. Douglass Houghton. vii + 119 pp. + frontisp. Wayne Univ. Press, 1954.

[5]Letters of I. A. Lapham, pp. 324-337, copies in the manuscript collection of the Ohio Historical Society Library, Columbus.

[6]George N. Fuller, ed. Geological Reports of Douglass Houghton. pp. 33-34. Lansing, 1928.

thence by canoe down the Grand River past the future site of Lansing; he explored the Maple River as far north as Gratiot County, then descended to Grand Rapids, all without benefit of highways.

Or consider the following, from Bela Hubbard's report on Wayne County in 1838: "Marshes or wet prairies comprise extensive tracts. . . . Indications are apparent which prove that very many, at least, of these peat marshes had their origin in the labors of the beaver, aided by the natural conformation of the surface. . . . About fourteen sections, two-thirds of which are in the town of Hamtramck . . . are of the character above described; but not more than one-half this extent is actual prairie. This yields an abundant growth of wild hay. The marsh is now in the progress of successful drainage. . . . According to reports of Indians, beavers disappeared from this region thirty years ago. Their numbers previous are said to have been incredible."

Because of the unbroken and largely uninhabited wilderness that occupied all but the southern part of the Lower Peninsula, detailed botanical and zoological surveys were possible only along the major roads that crossed the State from east to west. The "Chicago road," following the route of an old Indian trail, ran from Detroit to Clinton, Jonesville, Coldwater, Sturgis, and on westward. Another possible road led to Ann Arbor, Jackson, Marshall, Kalamazoo, and St. Joseph. We shall see how the actual surveys were influenced by the existence of these roads, and the towns along the roads.

BOTANICAL ACTIVITIES OF THE SURVEY

Most of what is known, or surmised, about the botanical work of the Geological Survey is derived from the work by Eaton and Wright mentioned above; from the geological reports made by Houghton to the Michigan Legislature (including the report by John Wright on the field season of 1838); and from the plant specimens collected by the members of the Survey from 1837 to 1840, and now preserved in the herbarium of The University of Michigan at Ann Arbor.

The specimens are approximately 800 in number, representing fewer than 600 species. They provide much information about the routes of the field parties in each year, but the data accompanying the plants are often incomplete or misleading, and must be interpreted with caution. It appears that the collections came to the University Herbarium from several sources. Whether or not any of them have been continuously in University hands since 1840 or before is not known. Some of them bear the original field labels written by Abram Sager (Fig. 1), Bela Hubbard (Fig. 2), John Wright (Figs. 8,9), or George Bull (Figs. 10,11), or by Houghton himself (a few only). More than half the specimens in the herbarium seem to have been duplicates, the labels for which were prepared 30 years or more after the plants were collected.

It is surmised that most of the existing collections, including duplicates, remained in the possession of the University until about 1868, when Mark W. Harrington (1848-1926), later a distinguished educator, became an assistant in the University Museum. As part of his duties he is said to have catalogued the

herbarium, collected and identified specimens, and prepared collections for exchange. Harrington was later (1873-1876) primarily responsible for the development of the collections in the Museum.[7] Whatever his duties may have been, a very large proportion of the labels on the First Survey specimens are in his handwriting (Fig. 4). Many others are in the hand (Fig. 3) of John F. Eastwood (-1911), an assistant in the Museum from about 1871 to 1875 and later a college teacher of chemistry.

Another handwriting (Fig. 5) that appears on miscellaneous old collections in the Michigan herbarium, and on many of the specimens collected by the botanists of the First Survey, although bold and distinctive, is thus far unidentified. It is presumed to be that of another museum assistant. One interesting label in this hand, on a specimen of *Erythronium albidum* from Ann Arbor, probably was written between 1875 and 1880, as it includes the words "Frederick & Ferris ('77)." Because this particular label was written on the back of one of the original labels prepared by John Wright for a plant collected in 1838, I suppose the *Erythronium* was collected about the time the First Survey plants were being mounted for the University Museum, and that some of the original labels were discarded and used for scrap-paper. We have no direct evidence as to the date of mounting of any of the specimens collected between 1837 and 1840, except that on one sheet of *Chenopodium ambrosioides* there is a note by V. M. Spalding, stating that the plant came from the "Houghton collection," and that when it was mounted, on January 26, 1880, the original odor of the plant was still strong!

Some of the duplicates from the First Survey collections seem to have found their way into the private herbarium of Abram Sager, which was presented to the University in 1886; at least a few specimens from Sager's herbar-

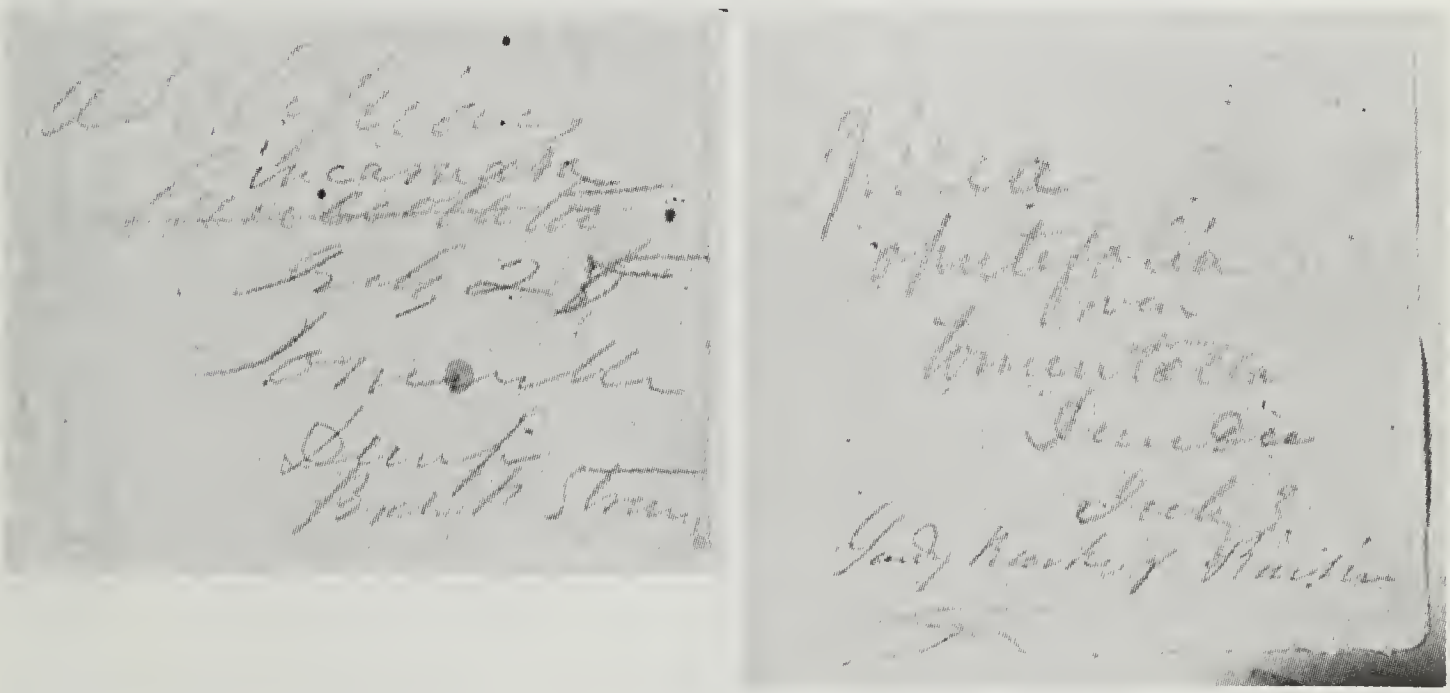

Fig. 1. Handwriting of Abram Sager, slightly less than natural size, from specimens collected in 1837.

[7]E. B. Mains. Univ. Mich. Encyc. Surv. 1444-1446. 1956.

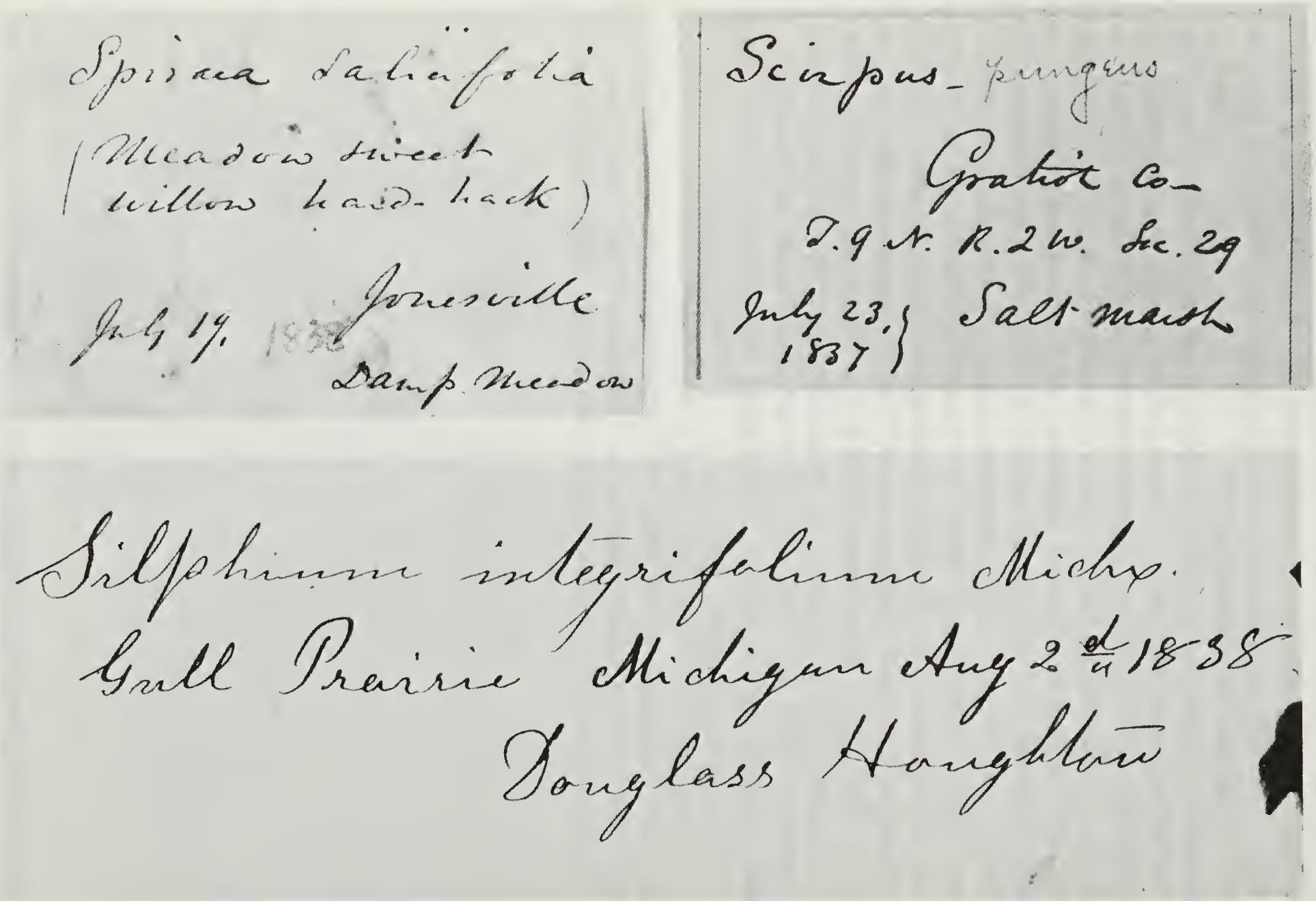

Fig. 2. Above, handwriting of Bela Hubbard, about natural size, from specimens collected in 1837. The date "1838" is a later addition. Below, handwriting of Elizabeth C. Allmendinger, about natural size, probably 1870-1880. The specimen was presumably collected by Wright and Bull, not by Houghton.

ium, though cryptically labelled, bear dates and localities indicating their connection with the First Survey. An even larger number of duplicates apparently came into the possession of Miss Elizabeth C. Allmendinger (1837-1909), a gifted amateur botanist who lived in Ann Arbor, and whose herbarium was eventually given to the University. The duplicates from the Allmendinger collection often bear labels (Fig. 2) indicating Houghton as the collector, even though from known dates and localities it is clear that the plants actually were collected by others.

In addition to all the above, there is a surprisingly large number of specimens that bear no labels at all except comparatively recent ones prepared with a typewriter, or written by herbarium assistants of the period 1920-1930.

Thus the specimens now in the Michigan set have been treated in a variety of ways, and not always for their good. The plants for the most part were carefully collected and pressed; many of the specimens are of excellent quality, and many of them are still in an excellent state of preservation, but as noted above many are inadequately documented. More of this below, in the discussion of the collections made in the different years of the Survey.

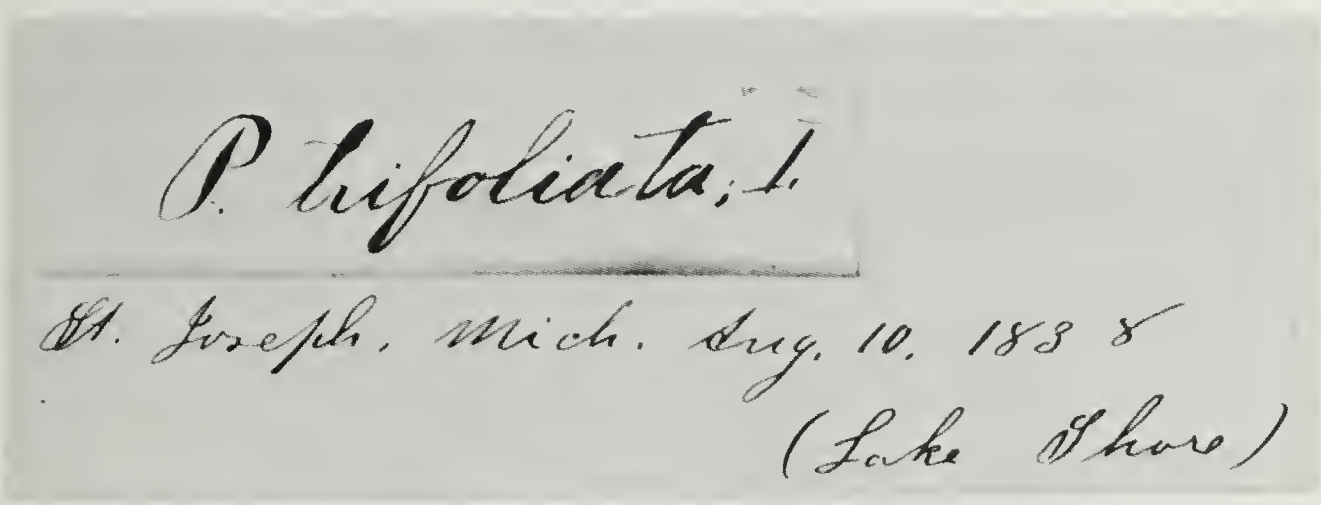

Fig. 3. Handwriting of John F. Eastwood, about natural size, probably 1871-1875.

THE SURVEY IN 1837

The Survey proceeded slowly during the first year. The State appropriated $3000.00, mostly to be spent on field expenses. Houghton and his assistants, with one exception, served without salary. The Botanical and Zoological departments were united under the direction of the principal assistant, Dr. Abram Sager (1810-1877), who was later Professor of Botany and Zoology, and ultimately Dean of the Medical School, at the University of Michigan.[8] Sager was primarily interested in zoology, but apparently devoted some effort to botanical collecting. Houghton's report dated December 1, 1837, says "The Botanical and Zoological departments have received due attention and larger collections of specimens have been made than could have been anticipated."

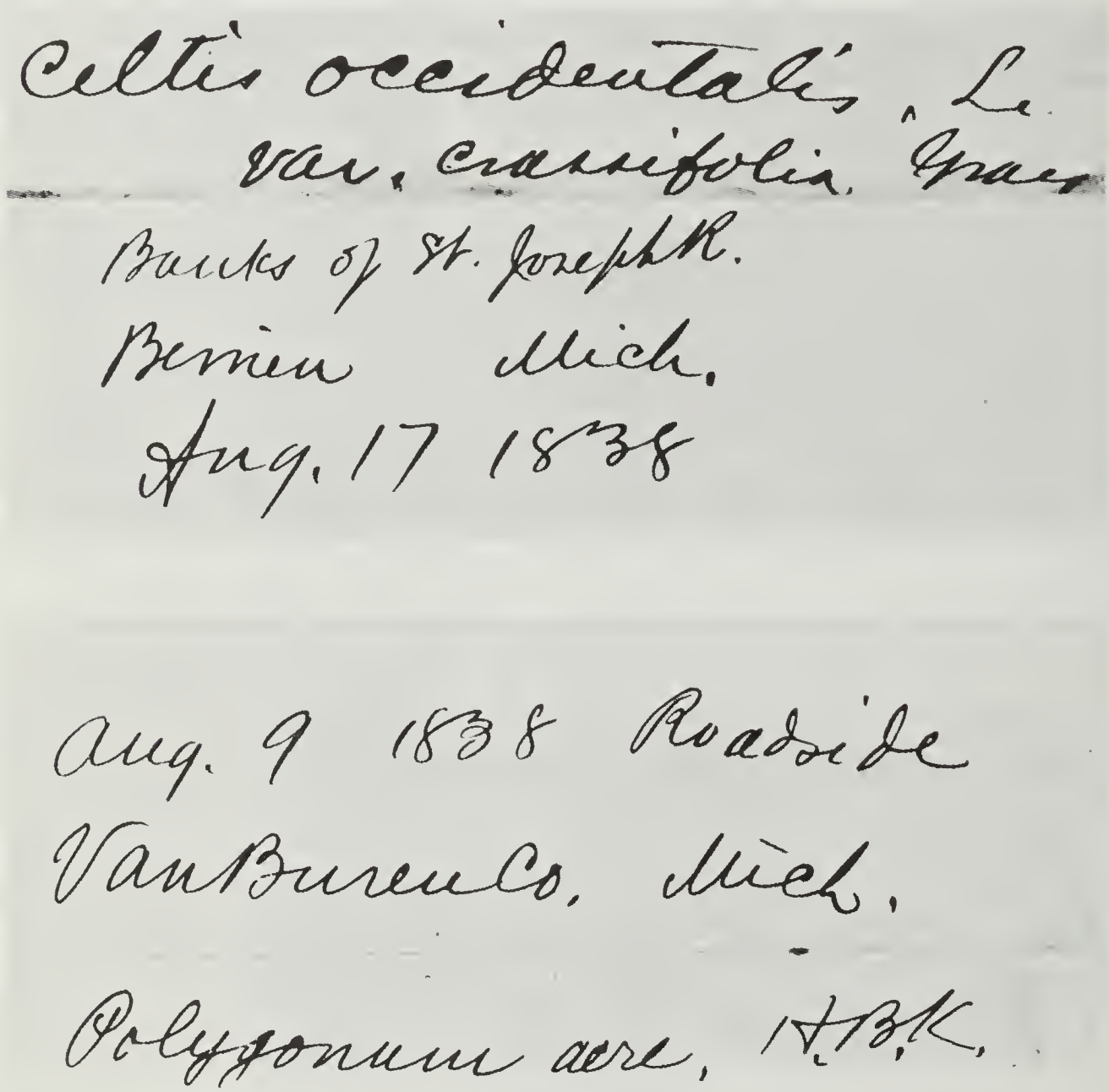

Fig. 4. Handwriting of Mark W. Harrington, about natural size, probably 1870-1880.

[8]For a brief notice of Sager, see E. B. Mains, in The University of Michigan[,] an encyclopedic survey. p. 1444. 1956.

In a report dated January 22, 1838, he said further:[9] "The departments of Botany and Zoology, under the more immediate direction of Dr. Abraham [sic] Sager, principal assistant, have received due attention. Extensive collections of plants have been made, and the preparatory steps taken towards arranging a Flora of the state."

There are about 160 herbarium specimens that we suppose were collected in 1837. These are primarily from a series of localities extending from Monroe County westward to St. Joseph County and north to Kalamazoo (Fig. 6). Somewhat fewer than half the sheets bear contemporary labels in the hand

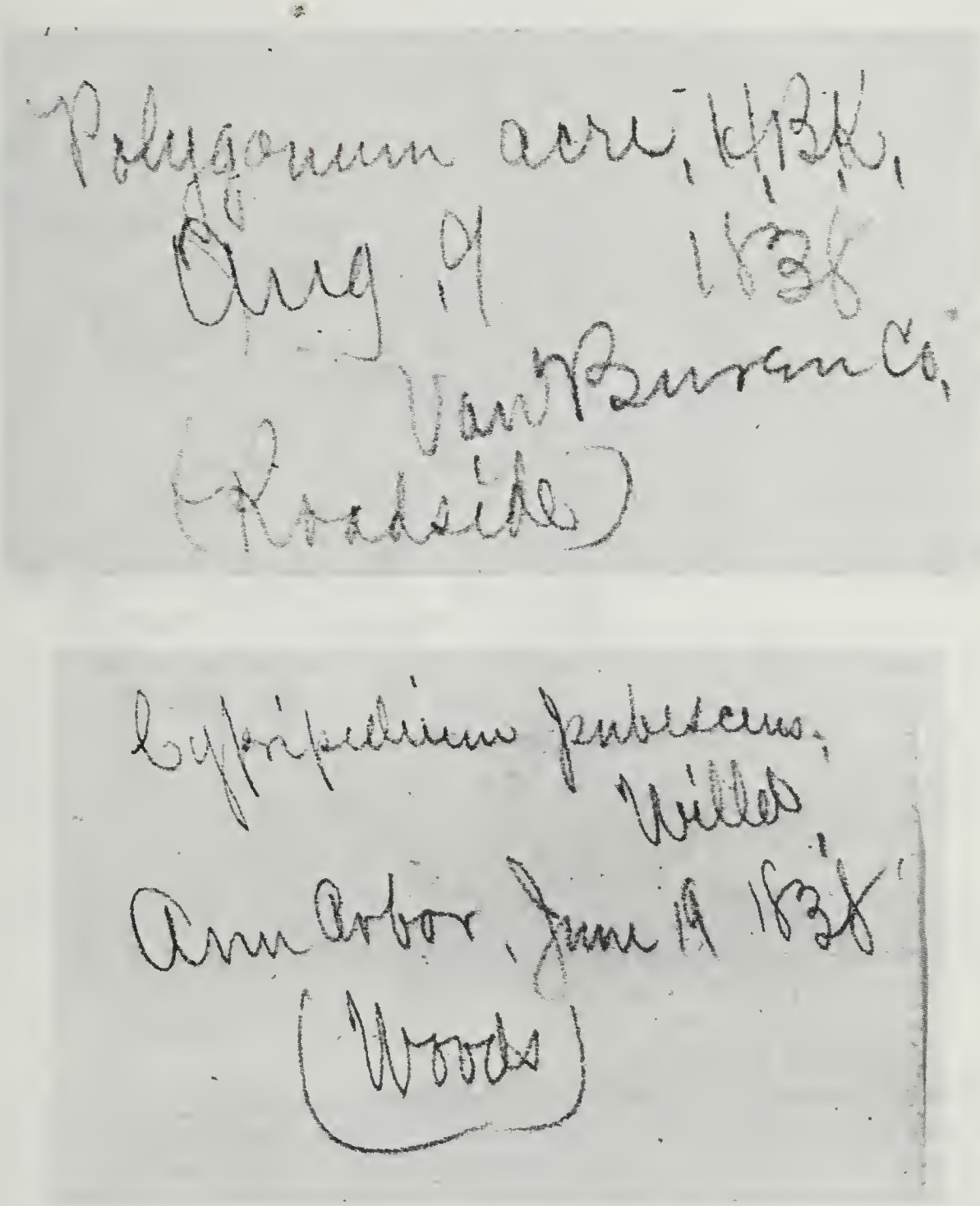

Fig. 5. Handwriting presumed to be that of a museum assistant at the University of Michigan, 1870-1880, about natural size. Many of the duplicate labels, especially of the 1838 collections, are in this hand.

[9]Fuller, op. cit., p. 137.

of Bela Hubbard.[10] This is especially interesting because the labels for 1838-1840, almost without exception, are written by other persons. It is surmised that the specimens labelled by Hubbard may have once formed a part of Houghton's private herbarium, i.e. duplicates that were especially

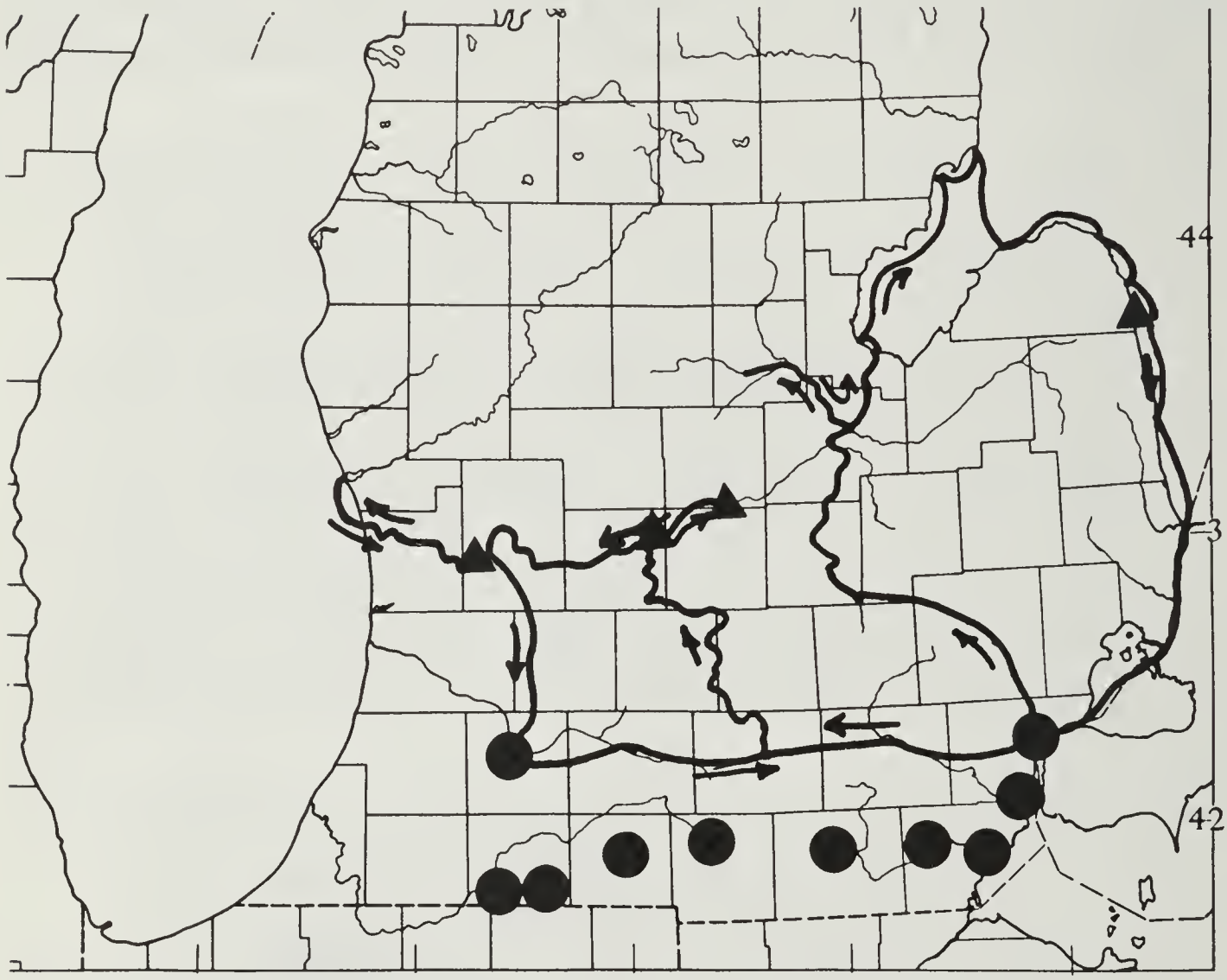

Fig. 6. Localities where plants were collected in 1837 by the Botanical Department of the Geological Survey (dots), and by Douglass Houghton or his assistant (triangles). Houghton's travels, as outlined in his field diary, are indicated by heavy lines.

[10]Bela Hubbard (1814-1896) was Houghton's principal geological assistant, who worked with him in the Geological Survey from 1837 to 1845, and accompanied him on many of his travels in Michigan. One of his duties seems to have been that of a secretarial assistant, to assist Houghton in keeping records and field notes. A transcript of Houghton's field notes for 1837 and 1838, for example, is in Hubbard's hand in the original volume of such notes, between pages copied earlier by Houghton himself, and the field record for 1839 and succeeding years, also in Houghton's hand. Hubbard's writing was distinctive, easy to recognize and easy to read (Fig. 2). Its presence on the labels of 1837, and on no others, is alluded to in the text. For a short biographical sketch of Hubbard, who later became a well-known figure in Detroit, see Rep. Mich. Acad. 4: 163-165. 1904.

ticketed by Hubbard for his superior.[11] The month and day of collection usually appear on Hubbard's labels, but the date 1837 appears on one sheet only (*Dulichium arundinaceum*, Branch Co., Aug. 1, 1837).

About 20 sheets not labelled by Hubbard, but also apparently collected in 1837, bear tickets in what seems to be the writing of Abram Sager; again but a single sheet (*Heuchera americana*, Dundee, July 3, 1837), is dated as to year.

Most of the rest of the collections in this series (about 60 sheets) seem to have been labelled long after they were collected, as described above. They have labels by Miss Allmendinger, Harrington, Eastwood, or the unknown person who seems to have been a museum assistant of the Harrington period. Of all the labels written by these copyists, the year is given as 1838 in about 25 instances, and 1837 in 2 or 3 instances only. It is surmised that the copies were made from the original 1837 labels, which ordinarily did not record the year of collection.

Even in the face of incomplete and sometimes conflicting data, we can say with some assurance that these collections were made by the field party of 1837, and not by Houghton himself as some have supposed. Houghton left Detroit for Ann Arbor, Jackson, and the upper valley of the Grand River about the same time that plant collections began in Monroe, and his field diaries show that his routes for the rest of the summer never coincided with the road that was travelled by the botanical collectors.[12] It appears from an existing copy of Abram Sager's report for the summer, moreover, that the latter travelled the very route indicated by the sequence of plant collections, namely from Monroe to Dundee, Adrian, Jonesville, and Coldwater.[13] We know pretty certainly, also, that the "1837" collections could not have been made in 1838, for the routes of the 1838 collectors are well documented, and it is clear upon comparison of the two series of dates and localities that the two sets of plant collections could not have been made during the same season by a single party. After the 1838 season there was no formal plant collecting, and there were but few specimens from 1839 and 1840, these usually clearly attributable to Houghton himself.

It seems probable that most of the specimens from along the route from Monroe to White Pigeon and Kalamazoo were actually collected by Dr. Sager, who was after all in charge of the botanical and zoological aspects of the Survey. Bela Hubbard's duties were primarily geological in nature, and it

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[11]At least a part of Houghton's herbarium was given to the University in 1864 by his widow, Mrs. R. R. Richards; cf. Regents' Proceedings 1864-1870, p. 39. June Meeting, 1864. Mains (op. cit. p. 1445) reports that the herbarium consisted of 9,000 specimens. Some of Houghton's own specimens are identifiable as such because the name DOUGLASS HOUGHTON is stamped on them in small black capital letters. The collections from the 1831 and 1832 expeditions, almost all of which are also labelled in the hand of Bela Hubbard, are thus stamped.

[12]Douglass Houghton. Transcript of field journal. pp. 53ff. Manuscript, Michigan Historical Collections.

[13]Douglass Houghton. Transcript of field journal. Abstracts from Dr. Sager's notes [for part of the summer of 1837]. p. 95. Manuscript, Michigan Historical Collections.

seems likely that he was not with Sager's party for any length of time, even though as noted above he wrote the labels for many of the existing specimens.

In addition to the specimens listed in Table 1, there are a few that almost certainly were collected by Houghton himself, or by Hubbard, in 1837. The dates and localities on these specimens correspond precisely to those of Houghton's known itineraries, and some of the species (from the vicinity of salt springs) are mentioned in his diaries. The species represented by specimens include the following: *Scirpus olneyi* and *Samolus parviflorus,* from Gratiot County; *Triglochin palustre,* from Ionia County; *Triglochin palustre* and *Samolus parviflorus,* from Kent County; and *Goodyera pubescens,* from White Rock, southeastern Huron County.

TABLE 1. Collections made in 1837, presumably by Abram Sager or those in his party, in the southern counties of Michigan. For each locality the total number of collections is entered in one column, and the number of collections bearing the original label in Hubbard's hand in a second column. Hubbard seems often to have recorded merely the name of the county in which the collection was made; see county names in the Gazetteer.

County	Locality	Date	Total	Labelled by Hubbard
Monroe	Monroe	June, or undated	6	3
		June 20-July 1	10	5
	Dundee	July 3	4	1
Lenawee	Adrian	undated	2	1
		July 6-8	7	2
	Lenawee	July 14	1	1
Hillsdale	Hillsdale	July, or undated	12	4
	Hillsdale, or Hillsdale Co.	July 1-24	6	1
	Jonesville	July, or undated	2	2
		July 12-25	17	12
Branch	Branch, or Branch Co.	July 17-August 1	8	4
	Mason, or "Masonville"	July, or undated	2	
		July 19-30	7	4
St. Joseph	St. Joseph, or St. Joseph Co.	August 2-8	8	5
	Sherman	undated	1	
		August 1-2	2	2
	Sherman prairie	August 2	1	1
	Sturges prairie	August 2	3	1
	White Pigeon, or (August 8), "Pigeon"	August, or undated	5	
		August 4-23	13	6
	Pigeon prairie	August 11, 24	2	1
Kalamazoo	Kalamazoo	August	2	1
		August 23-September 5	8	5

THE SURVEY IN 1838

During the winter of 1837-38 the Survey was reorganized on a larger basis. The legislature passed, on March 22, 1838, an expanded act providing for a Survey of four departments, namely geological and mineralogical, zoological, botanical, and topographical. A condition of the act, which ultimately proved detrimental to the progress of the survey, provided that 17 specimens of each collection should be taken whenever practicable, for distribution by the regents "amongst the university and its branches."[14]

As soon as the act of 1838 was passed, Houghton sought and found a competent person to take charge of the Botanical Department of the Survey. This was Dr. John Wright (1811-1845), who like Houghton had been associated with Amos Eaton, and who was the co-author of a creditable local flora published two years earlier.[15] Wright gave up what was said to be a "lucrative practice" of medicine in Troy to accept the position in Michigan. As Botanist of the Geological Survey, he received $1500.00 for the season. This seems a fairly good salary when measured against those of the Director of the Survey and the Governor of Michigan, each of whom received $2000.00 for his services during the same period.[16] At the time of Wright's appointment a Mr. George H. Bull was appointed as "sub-assistant to the Botanical Department," at a salary of $800.00.[17] Dr. Abram Sager remained in charge of the Zoological Department, with the services of two assistants.

A report of the botanical work of 1838 was published by Wright.[18] This consisted of a brief introductory statement, followed by an alphabetical list of names of "between eight and nine hundred native or naturalized species" of flowering plants and ferns. Because the report is a list of names and no more, without any supporting information about localities, dates, habitats or collectors, it is not very useful, but it is interesting as providing records of certain weeds that had already been introduced into Michigan, and

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[14]Acts of the Legislature of the State of Michigan 1838: 119-121. 1838.

[15]John Wright & James Hall. A catalogue of plants growing without cultivation in the vicinity of Troy. 42 pp. Troy, [New York], 1836.

[16]Michigan Senate Documents 1839: 109, 117. 1839.

[17]I have not been able to learn anything about George Bull's life outside of his connection with the Survey. He seems to have been an efficient assistant, with some degree of literacy and some interest in botany. Amos Eaton named a new species, *Gymnandra bullii,* and dedicated it to "Mr. Geo. Bull, Ast. Bot. to Mich. Commission." When Wright resigned after the 1838 season, Bull continued as an assistant to Houghton. He accompanied Houghton on a long trip along the shores of the upper Great Lakes during the summer months of 1839, and apparently was responsible for most of the 1839 plant collections that are still extant. At the conclusion of that season's field work he travelled to New York at Houghton's request "with a suite of the plants collected this year, for the purpose of submitting them to the examination of Dr. Wright . . ." (Houghton, letter to John Torrey, 1 Nov. 1839), but whether he came originally from New York or from Michigan I do not know. He is referred to at least once by Houghton as "Dr. Bull," but this seems to have been a slip of the pen.

[18]In 2nd Ann. Report of the State Geologist (Michigan House Doc. 1839: 421-442. 1839; Mich. Senate Doc. 1839: 305-326. 1839; also in Fuller, op. cit., pp. 223-251.

records of native plants, particularly prairie species, that are now very rare in Michigan, or quite unknown except from the collections of the First Survey. In the words of the report, the collections of 1838 were made "in the two most southern ranges of counties of the state, from the Detroit river to Lake Michigan, excepting the county of Monroe, and in St. Clair county." Actually the data from existing specimens show that the work was concentrated in the following counties (see Fig. 7): St. Clair (May 25-June 11), Washtenaw (June 19-July 2), Jackson (July 5-18), Kalamazoo (July 23-Aug. 7), Van Buren (Aug. 9), Berrien (Aug. 10-20), Cass (Aug. 20-28), St. Joseph (Sep. 8-12), and Lenawee (Sep. 14-24). Wright, in his report, explained why these particular localities were chosen, alluding to and at the same time perhaps understating the difficulties of making extensive field collections in the wilderness:

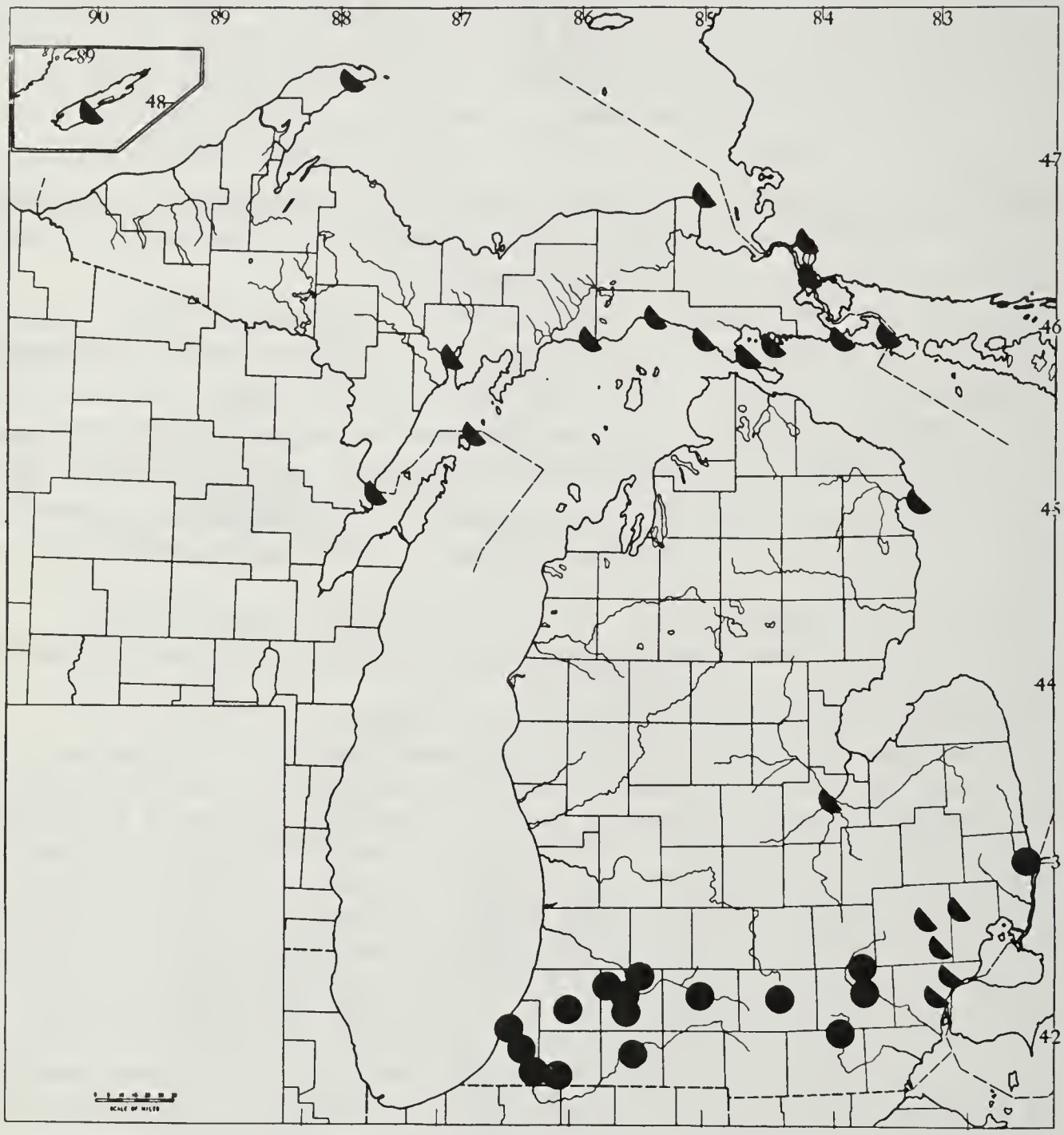

Fig. 7. Localities where plants were collected in 1838 by the Botanical Department of the Geological Survey (dots), and in 1839 and 1840 by Douglass Houghton or George Bull (half-dots).

> The extensive requisitions of the bill, making it obligatory . . . to collect and preserve . . . seventeen specimens of each kind . . ., has been the principal inducement for confining the sphere of action to the above mentioned portions of the state. The bulky apparatus necessary to be conveyed from place to place, during the excursions, for the preservation of the plants in such extensive collections, and the requisite conveniences for drying and protecting them, render it impracticable to examine a very great extent of country, and particularly such portions of it as are unsettled, during a single season. . . .

Wright went on to say that with Mr. Bull's assistance he had examined the species enumerated in the report, and collected specimens of each, "amounting, in all, to about nine thousand, which are now in an excellent state of preservation. More than this number of species were observed growing in the counties examined, but they were not in a proper condition for the selection of specimens. . . . A considerable number of cryptogamous or flowerless plants were also noticed and secured."

We know very little about the fate of the 9000 and more specimens that were so laboriously collected in 1838, but we must admire the diligence and determination displayed by Messrs. Wright and Bull in gathering them. The field season lasted only about 100 days, which meant the field party had to dry 90 or 100 specimens every day, at the same time collecting as many as they could in sets of 17. Any field botanist who has tried to dry that many specimens, day in and day out, through a long summer, knows how much work is involved. The mere changing and drying of blotters in such quantities must have presented some problems, to say nothing of the careful selection of duplicates in large quantities, the labelling, packing, and otherwise safeguarding the specimens.

The largest existing set, as far as I know, is that at the University of Michigan. It consists of about 500 sheets representing more than 400 species. Like the collections of 1837, these probably came to the University from several sources. It may be that the Michigan set once included most of the duplicates; it is possible that many of these were destroyed by the disastrous fire in the herbarium in 1913, but this is not certainly known.[19] A considerable set of duplicates seems to have gone into Miss Elizabeth Allmendinger's herbarium, and perhaps an equal or even greater number into Houghton's private herbarium. Partial sets were sent by Wright or by Houghton to John Torrey and to Asa Gray, and these specimens may now be found at the New York Botanical Garden and at the Gray Herbarium of Harvard University. Other private collectors who received sets were George Thurber (1821-1890), who was professor of botany and horticulture at Michigan Agricultural College from 1859 to 1863, and Zina Pitcher (1797-1872), an early associate of Houghton in Detroit, and a Regent of the University of Michigan. Thurber's specimens may be found today both at Harvard and at New York, and Pitcher's at the U. S. National Arboretum. There is also a small set of grasses and sedges from the First Survey at the Tracy Herbarium of Texas A. & M. University, and additional specimens from other sets may yet be discovered.

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[19]Mains, op. cit., p. 1447.

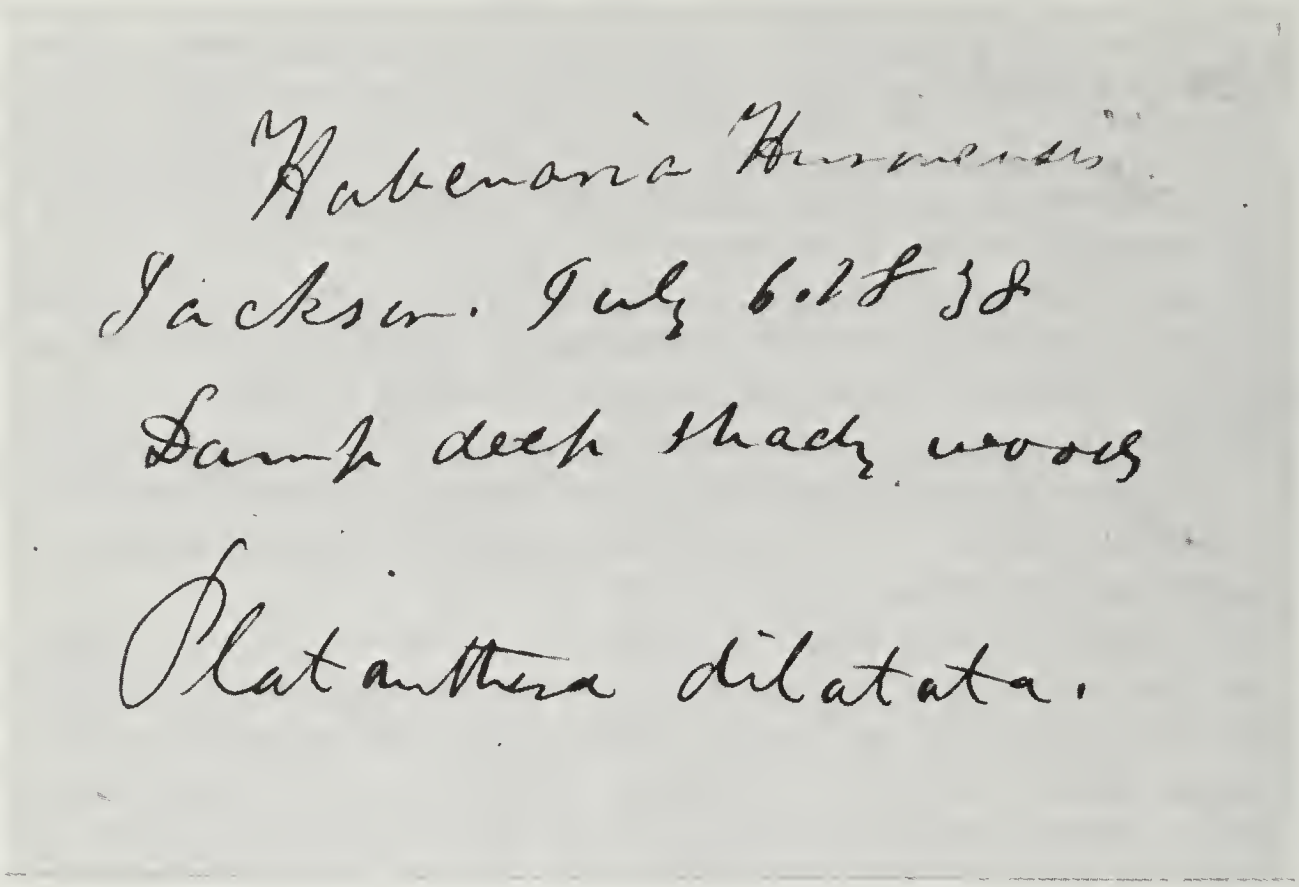
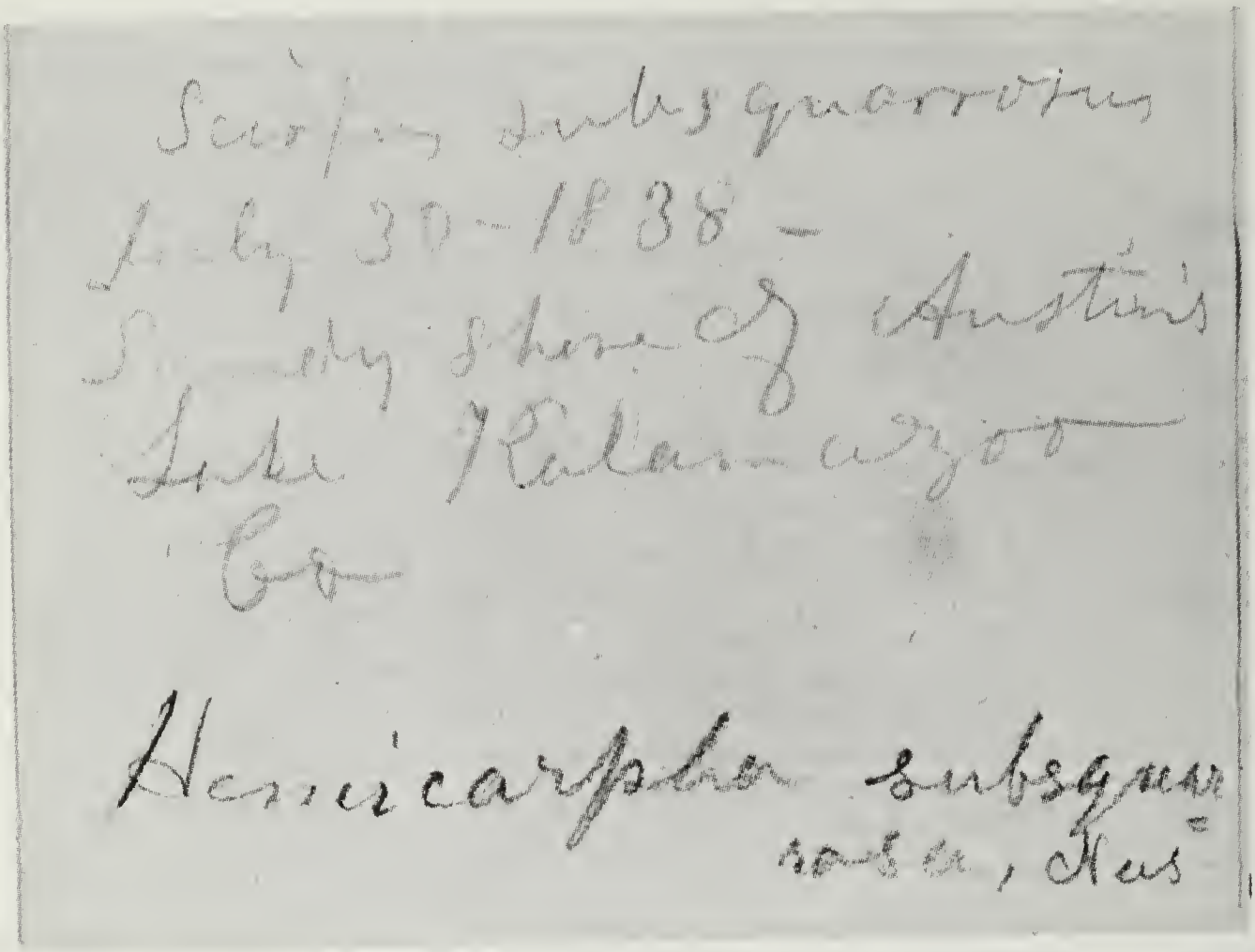


Fig. 8. Handwriting of John Wright, about natural size, from specimens collected in 1838. The words "Platanthera dilatata" appear to be in the hand of Asa Gray. Gray visited Detroit and Ann Arbor in August, 1838, and may have seen this specimen at that time. The words "Glyceria aquatica Smith" on the lower label are a later addition.

TABLE 2. Dates and localities of botanical collections in Michigan, May 25-September 24, 1838. The more general localities are those at which the majority of collections were made; other localities near these much-collected places are listed secondarily.

County	Locality	Inclusive dates	Approximate number of collections
St. Clair	Port Huron Ft. Gratiot Black River Clyde Lake Huron Shore above St. Clair River Head of St. Clair River 6 miles below Port Huron	May 25-June 11	60
Washtenaw	Ann Arbor Marsh near Whitmore Lake Northfield, sphagnous swamp Banks of Huron River Sphagnous swamp around lakes 2 miles west of Ann Arbor Pleasant Lake	June 19-July 2	110
Jackson	Jackson Grand River	July 5-18	75
Calhoun	Marshall	July 20	6-10
Kalamazoo	Kalamazoo Sand Lake Austin's Lake Grand Prairie Along Kalamazoo River Lake 3 miles east of the village Gull Prairie Gull Lake	July 23-August 7	75
Van Buren	None stated	August 9	6-10
Berrien	St. Joseph Lake [Michigan] shore Mouth of the Paw Paw River St. Joseph River at Berrien	August 10-20	35
	Niles	August 20-21	5
Cass	Edwardsburgh Edwards Prairie	August 20-28	40
St. Joseph	Centreville Hog Creek	September 8-12	15
Lenawee	Clinton Wolf Lake	September [7?]-24	10-15

In the Michigan collection the specimens collected in 1838 are labelled in a variety of ways, like those from other years of the First Survey. Perhaps a third of them are provided with the original labels in the hand of John Wright (Figs. 8,9), in that of George Bull (Figs. 10,11), or, in a few instances, in another hand. The rest of the sheets lack original labels; such information



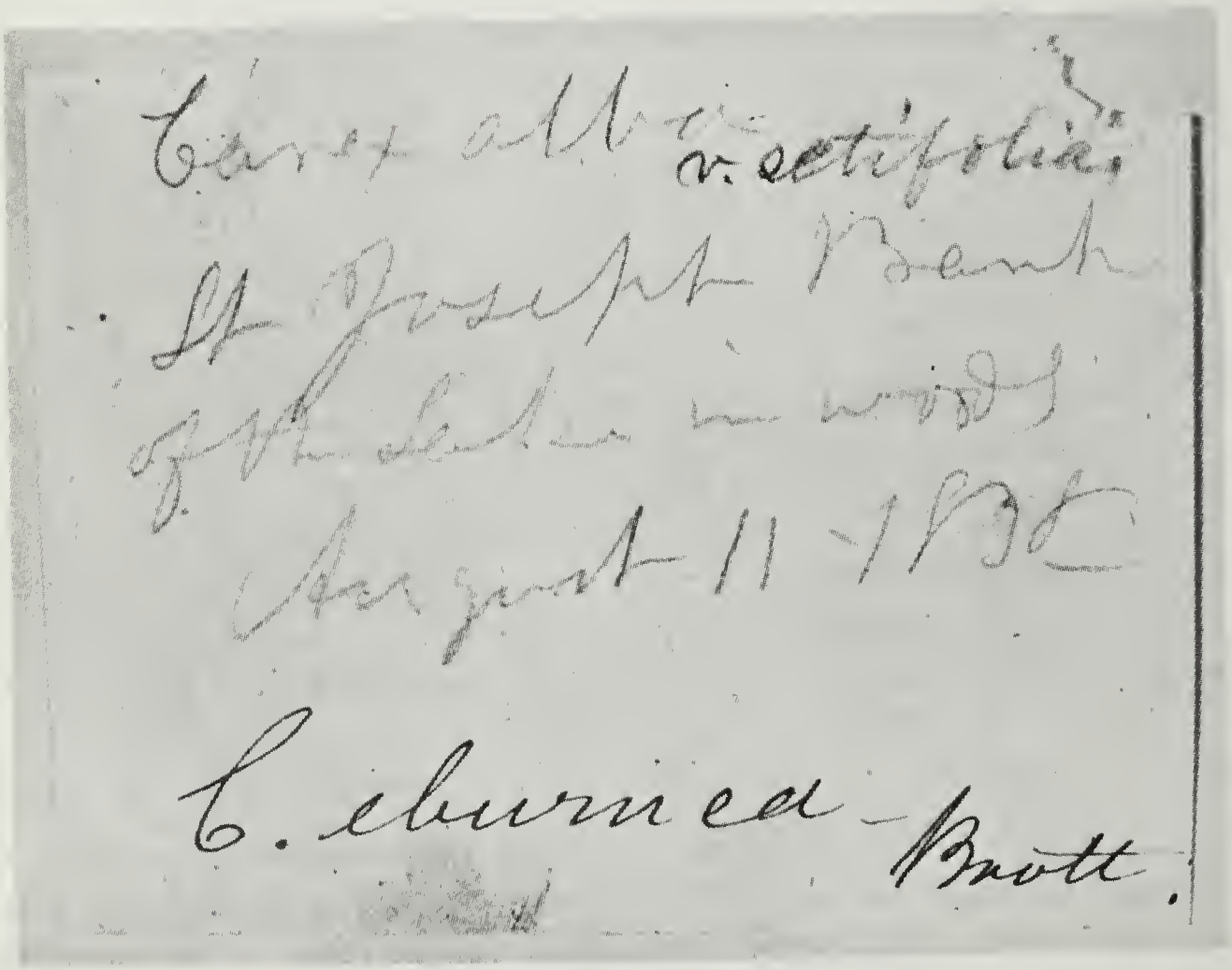


Fig. 9. Handwriting of John Wright, about natural size, from specimens collected in 1838. The words "Hemicarpha subsquarrosa, Nees," "v. setifolia," and "C. eburnea Boott," are later additions.

as they carry has been provided by Miss Allmendinger, by Harrington or one of his contemporaries, or even by others at much later dates. Bela Hubbard's hand, for what reason I do not know, does not appear on any of the collections of 1838. Because the specimens of 1838 are so much more numerous than those of 1837, and because the year of collection was almost invariably written on the original labels, there is little doubt as to the exact localities and dates of collections made in this second season of the Survey.

THE SURVEY IN 1839 AND 1840

Botanical work of the Survey, as such, was not continued after the 1838 season. The assistants in the Botanical and Zoological Departments, with the exception of George Bull, resigned, presumably because they were not expecting support for the field season of 1839. Some years after this event Alexander Winchell, the geologist, inquired of the widow of Abram Sager, and was informed that the "resignations were provoked by ignorant criticisms and caricatures indulged in by members of the legislature in public debates on questions connected with the survey, especially in the departments."[20] Reading between the lines, one may suppose that as the State of Michigan was not in a good financial condition, the legislators could see little practical value in paying for more collections of stuffed birds and dried flowers.

In any event, the State Senate inquired formally of the Director of the Geological Survey, "What loss, injury or detriment might result from a temporary suspension of said geological survey?" and "What part of such survey, in particular, would be prejudiced by such suspension?"

Houghton, in his reply to the Senate on March 7, 1839, emphasized especially the harm that would result if the work of the Botanical and Zoological Departments were to be discontinued. Of John Wright he said "it was only after the most urgent solicitations, and at much pecuniary sacrifice upon his part, that he was induced to accept the appointment; relying upon the faith of the state to complete the work which he had been induced to undertake. . . . Even the most temporary suspension of the work would eventuate in the loss of the scientific and practical matter which has been collected in this department of the survey, while it certainly would be acting in no good faith to the head of that department."[21]

Wright seems to have returned to Troy early in October, 1838,[22] and perhaps never returned to Detroit for any long period. His report on the 1838 field season, mentioned above, was dated at Detroit, January 1, 1839.

In Houghton's 3rd Annual Report, dated February 3, 1840,[23] he alluded to the resignation of the botanical and zoological assistants, and con-

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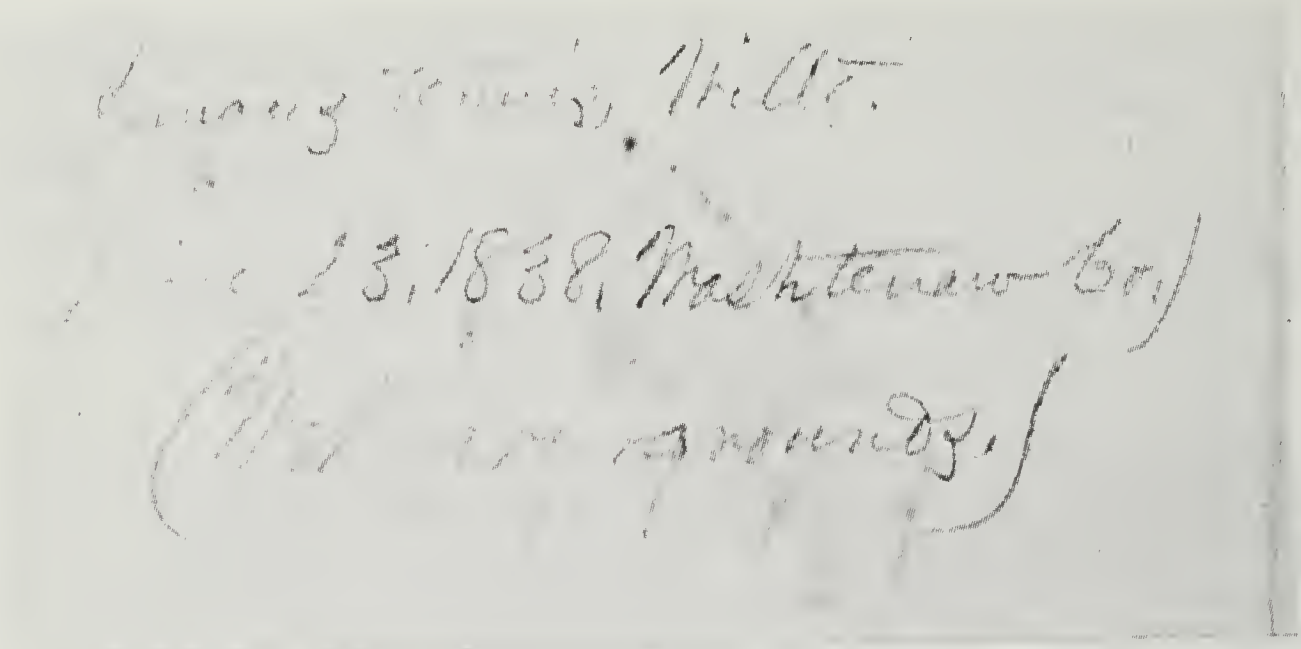
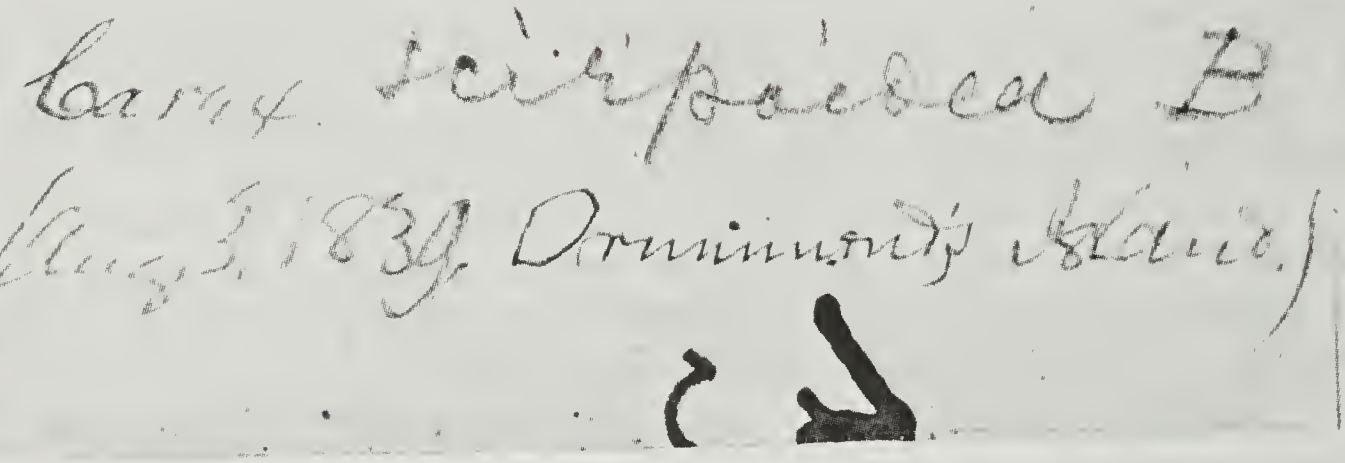
[20]Quoted in George P. Merrill, ed. Contributions to a history of American state geological and natural history surveys. Bull. U. S. Natl. Mus. 109: 175. 1920.

[21]Michigan Senate Doc. 1839: 463-466. 1839; Fuller, op. cit., pp. 340-345.

[22]Letter from A. Sager to Houghton, 28 Sep. 1838, in Michigan Historical Collections.

[23]Michigan Senate Doc. 1840, vol. 2: 87. 1840; Fuller, op. cit., pp. 395-396.





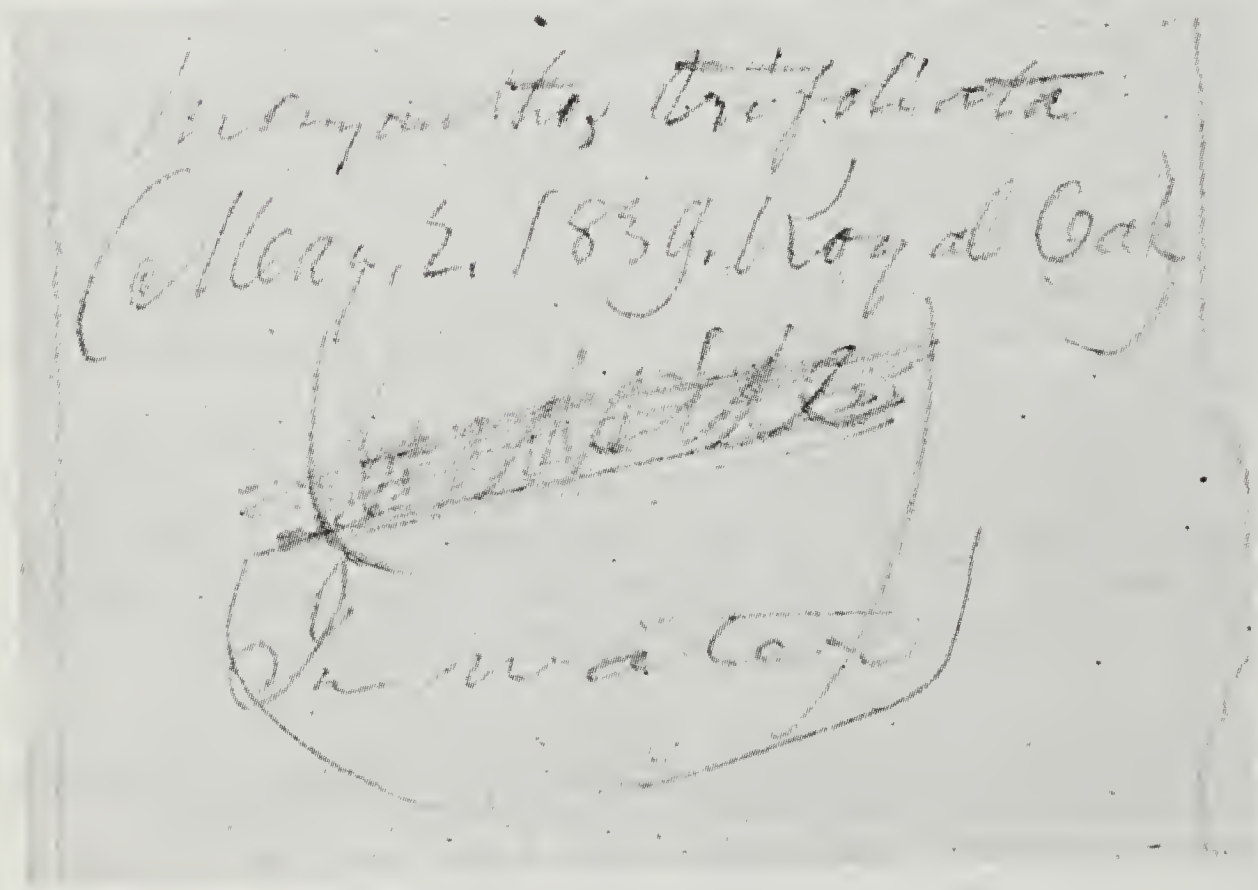


Fig. 10. Handwriting of George H. Bull, about natural size, from specimens collected in 1838 and 1839.

tinued: "In order to preserve from absolute loss, what had already been done, and to make such advance as the circumstances might admit, a single sub-assistant, Mr. Geo. H. Bull, retains his situation, and by his assistance I have been enabled to place the botanical portion of the work in such condition that it may be of use in the final and connected reports which are required to be made."

Unfortunately for Houghton's expectations of a "final and connected report," the legislature by an act approved March 28, 1840, abolished the

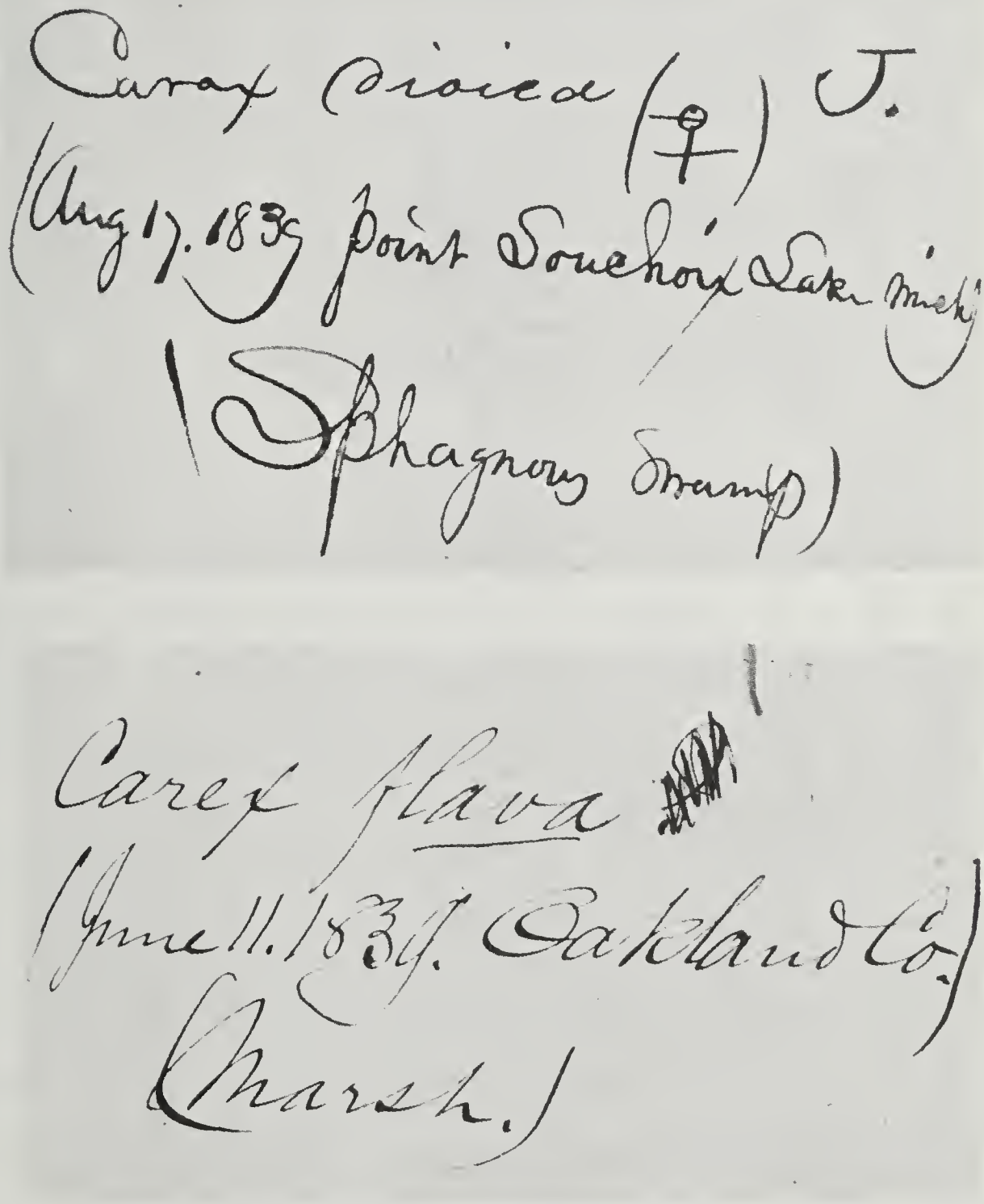


Fig. 11. Handwriting of George H. Bull, about natural size, from specimens collected in 1839.

zoological and botanical departments, and the survey became officially restricted to its strictly geological and topographical aspects.[24]

The University Herbarium contains about 60 specimens that were apparently collected in 1839. Most of them were probably collected by George Bull, and about one-quarter of these bear a contemporary label in what I suppose is his handwriting (Figs. 10,11). There are also in the herbarium at least 4 specimens dated 1840, one with an original label by Hubbard. The rest of the 1839 and 1840 collections, aside from those labelled by Bull or Hubbard, evidently were eventually handled like those of 1837 and 1838, and by the same people; their labels reflect the work of Miss Allmendinger, Harrington, and the rest.

According to a statement by Houghton, Bull spent a part of the early field season of 1839 on an independent venture into the south-central part of the state.[25] It is presumed that the following were collected by Bull; specimens marked with an asterisk (*) are thought to have been labelled by him:

Larix laricina	Royal Oak	April 26
Salix petiolaris	Royal Oak	April 30
Chamaedaphne calyculata	Royal Oak	May 2
Menyanthes trifoliata	Royal Oak	May 2*
Ribes americanum	Royal Oak	May 2
Aquilegia canadensis	Pontiac	May 24
Fraxinus quadrangulata	Washington, Macomb Co.	May 28
Ranunculus ?aquatilis	Pontiac	June 8
Arethusa bulbosa	Pontiac	June 8
Carex lanuginosa	Oakland Co.	June 11*
Carex buxbaumii	Oakland Co.	June 11*
Carex flava	Oakland Co.	June 11*
Collinsia verna	Saginaw Co.	June 21*

The rest of the collections of 1839 are from the northern part of Michigan. Houghton left Detroit on July 26, by steamer for Mackinac [i.e. Mackinac Island], where he arrived on May 28. Apparently Bull had preceded him there, for there are at least four collections (two of them labelled by Bull), dated at Mackinac, July 22-24. Four additional collections from the same place are dated July 28-30.

On August 2, as recorded in Houghton's diary, he left Mackinac in a small boat with Bull and three "day laborers." The party passed along the southern shore of what is now Mackinac County to Drummond Island, circumnavigated that island, ascended the St. Mary's river to Sault Ste. Marie, returned to Lake Huron and passed westward along the north shore of Lake Michigan as far as the mouth of the Menominee River. They visited Green Bay village and several of the islands in the bay, then left by steamboat for Mackinac on August 27.

The specimens in the herbarium may be summarized as follows:

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[24]Acts of the Legislature of the State of Michigan 1840: 126-127. 1840; Merrill, op. cit., p. 175.

[25]"Dr. Bull, the Sub. Asst. occupied a portion of the season in the interior of the state & a portion, in company with myself, on the coast. . . ." Letter, Houghton to John Torrey. 1 Nov. 1839. See Fig. 12.

My Dear Sir,

Your favour of the 24th ult has just come to hand. The few days which have elapsed since my return to winter quarters has left me but little time as yet to give ~~attention to~~ any attention, of consequence, to the details of the work under my charge P. of the Botanical department has received last —

The vacancy in ~~that~~ dept. of Botany made by the resignation of Dr. Wright, has not, as yet been filled; & but one sub-agt. has been employed (in the shape of Collector) during the past season — Dr. Bull, the sub. Agt. occupied a portion of the season in the interior of the state, & a portion, in company with myself, on the coast from the foot of Lake Superior to the mouths of Monomonee Riv. of Green Bay — These

Fig. 12. Handwriting of Douglass Houghton, in a letter to John Torrey, 1 November 1839.

County	Locality	Date	Number of specimens
Mackinac	Mackinac [Island]	July 22-30	8
Chippewa	Drummond Island (south or southeast side).	August 2-3	10
	Drummond Island (north side).	August 4	2
	Islands of St. Mary's River (below Sugar Island)	August 6	4
	St. Mary's River (Lake George to the Sault)	August 7	1
	Drummond Island (in the Detour Passage)	August 10	1
Mackinac	Goose Island	August 11	1
	North Shore (i.e. between St. Ignace and 9 miles west of Point aux Chenes)	August 14	2
	North Shore (from camp to 3 miles west of Menococien River)	August 15	1
Mackinac or Schoolcraft	North shore (from camp to east side of Point Seul Choix)	August 16	1
Schoolcraft	"Point Souchoix"	August 17	1
Delta	North shore (Little Bay de Noc)	August 20	1
?Menominee	North shore, Green Bay	August 21	1
Menominee	[Near mouth of Menominee River]	August 22	3
	"Louse Island, Mich." (=Rock Island, Wisconsin, at the tip of the Door Peninsula).	August 26	1

The collections of 1840 are but four in number. The dates and localities, when definitely stated, agree with those of Houghton's known itineraries as recorded in his field diaries. The specimens are as follows:

Kalmia polifolia	Whitefish Point, [Chippewa County]. June, the label partly in the hand of Bela Hubbard
Polystichum lonchitis	Lac Bay de Res, Lake Superior [Bete Gris Bay, Keweenaw County], June 30, 1840
Ranunculus reptans	Lake Superior, June 30, 1840
Listera cordata	Isle Royale, August 3, 1840

SPRING COLLECTIONS, 1837-1839

Because so many of the specimens are dated to month and day only, the year of collection must be inferred in many instances. This can be done with a high degree of confidence for specimens collected along the routes of the field parties at some distance from Detroit. A specimen labelled merely "Sherman, Aug. 1" can be assigned the date 1837 because the field party of that year is known to have been in the southern part of St. Joseph County for about 10 days in the first part of August.

In the vicinity of Detroit, however, it is quite another matter. The members of the Geological Survey were based in the city, and presumably had some opportunities to collect plants, if they wished, as soon as the spring flora began to appear and before the regular field parties began their work. Houghton himself was a competent botanist and may well have picked up an occasional specimen, as may Bela Hubbard, whose handwriting appears on so many of the 1837 labels. Sager was in the city in 1837 before leaving for the beginning of the work in Monroe County in mid-June. Wright and Bull must have been in Detroit at least for a short time in the spring of 1838 before they began work in St. Clair County on May 25. As the name of the collector

was never written on any of these early specimens, the copyists who labelled the specimens many years later had no idea who collected them, and it is now often impossible to guess who was responsible for them, and equally impossible to be sure of the year of collection.

Listed below are the spring collections in question. It seems likely that those labelled by Bela Hubbard were collected in 1837, as his writing appears on many other specimens that are confidently dated from that year, and on very few specimens except those collected in that year. The date of 1838 is presumably correct for the specimen of *Viola rostrata.* The other specimens in the list may have been taken in 1837, 1838, or 1839. For additional spring collections attributed to George Bull, see above under the account for 1839.

Populus tremuloides	Detroit, April 3, 1839	(label by Harrington)
Ulmus americana	Detroit, April 4, 1839	(label about 1870)
Lonicera canadensis	Detroit, April 23, 1839	(label about 1870)
Senecio aureus	Ann Arbor, May 15, 1839	(label by Allmendinger)
Viola rostrata	Detroit, May 22, 1838	(found 1952 in Houghton's copy of Beck's *Botany*)
Ranunculus flabellaris	Washtenaw Co., May 27	(label by Harrington)
Uvularia grandiflora	Wayne Co., May	(label by Hubbard)
Sarracenia purpurea	Oakland, June 8	(label by Hubbard)
Mitella nuda	Oakland, June 8	(label by Hubbard)
Cypripedium reginae	Wayne Co.	(label about 1870)
Juniperus communis	Grosse Isle, June	(label about 1870)
Silene virginica	Grosse Isle, June 12, 1838	(label by M. V. Cannon, ca. 1920)
Potamogeton berchtoldii	Grosse Isle, June 16	(contemporary label in unknown hand)
Lysimachia thyrsiflora	Squaw Island, Detroit River, June 16	(label by Hubbard)
Vicia americana	Gibraltar, June 15, 1838	(label by Harrington)
Lathyrus ochroleucus	Gibraltar, June 16, 1839	(label by Harrington)

BOTANICAL ACCOMPLISHMENTS OF THE SURVEY

The activities of the Botanical Department of the Michigan survey had a modest effect on contemporary botanical thought and literature. It is unfortunate that with the effective cessation of botanical work after the season of 1838, the complete withdrawal of support by the Michigan legislature in 1840, the death of Wright in April, 1845, and that of Houghton in October of the same year, the botanical part of the survey not only came to an end but also lost its principal advocates, and at the same time lost those who might have been able to prepare a useful and comprehensive report on the collections already made.

Wright continued his interest in the botany of Michigan until the end of his life.[26] After he returned to Troy he continued to correspond with Torrey

[26]Among the Sager documents in the Michigan Historical Collections is a letter from Thomas C. Brinsmade, Wright's medical associate in Troy. The letter is clearly dated April 25, 1845, and describes in painful detail the progress of Wright's slow decline and death from "pulmonary phthisis." Until the very last days he is said to have enjoyed talking and reminiscing about his experiences with George Bull in the field in Michigan. The standard biographical reference to Wright, that by S. E. Jelliffe in Howard A. Kelly's *Cyclopedia of American Medical Biography* (vol. 2, pp. 532-533. 1912) gives the date of his death as April 11, 1846, but apparently it took place a year earlier.

and consult him about matters of plant identification, but he noted in one letter (March 21, 1840) that he had brought very few plants with him from Michigan, and "those mostly single specimens." He went on to say "Mr. Bull my Assistant in Mich. has put up a bundle, & I have added a few in a separate parcel, for you. I have not strength to overhaul my plants to send you all I wish to."

Torrey and Gray, in the foreword (June 1, 1840) to their *Flora of North America,* state that "From Michigan, Dr. Houghton and Dr. Wright have furnished us with numerous plants." In the pages of the *Flora* these authors cited a few collections by Houghton and a few by Wright, but it seems unlikely that they received any very large number of plants of more than ordinary interest to them.

Wright's positive contributions after the work in Michigan were his list of plants published in the Michigan Legislative Documents for 1839, and his additions of Michigan records to Eaton and Wright's *North American Botany* in 1840. Both of these were in effect mere lists of names. Neither included information on distributions or habitats of the plants as they occurred in Michigan. The work of Eaton and Wright presumably became accessible to most practicing botanists of the time, but the 1839 list must never have enjoyed very wide circulation. It is interesting to speculate on the means employed by Wright in preparing this list for publication between the end of the field season in September, 1838, and the presentation of the report, which is dated January 1, 1839. In Michigan at that time there was no herbarium of any size that he could consult, and for his identifications he presumably depended upon his prior knowledge of the plants of the northeastern United States, and upon such works as the 7th edition of Eaton's *Manual* (1836), or L. C. Beck's *Botany of the Northern and Midland States* (1833). Perhaps the very need for haste in the preparation of the list prevented the inclusion of certain species that Wright did not immediately recognize, and did not have time or opportunity to study. For example the plant called *Gymnandra* (or *Besseya*) *bullii* seems to have been collected in 1838, but no notice was taken of it until it was described by Eaton in 1840.

With few exceptions the names in the 1839 list are those of plants that might be expected in southern Michigan today. The more difficult groups are not slighted; for example, there are 54 species of *Carex* in the list. On the other hand there are only 6 species of *Potamogeton,* this reflecting perhaps a lack of interest in aquatic vegetation on the part of the collectors. Many introduced weeds are recorded, some certainly for the first time from Michigan. These alien species included *Agrostemma githago* (called "Cockle" by Wright), *Cannabis sativa* ("Hemp"), *Datura tatula* ("Purple thorn-apple"), *Eleusine indica, Galeopsis tetrahit* ("Flowering nettle"), *Hibiscus trionum, Malva neglecta* ("Low Mallows"), *Nepeta cataria* ("Catnip"), *Leonurus cardiaca* ("Motherwort"), *Saponaria officinalis* ("Bouncing Bet"), *Trifolium pratense* and *T. repens* ("Red Clover" and "White Clover," respectively).

The list as a whole is of interest because of what it suggests with respect to the vegetation of southern Michigan before 1840, and the changes that

have taken place since that time. For example, as might be expected, one finds many characteristic plants of rich woodlands across southern Michigan (e.g. *Verbesina alternifolia, Aesculus glabra, Hydrastis canadensis, Agastache nepetoides, Hydrophyllum appendiculatum, Panax quinquefolius, Polymnia canadensis*), but some of these, like *Hydrastis* and *Panax,* are rare enough now to be exciting finds for a botanist. If they had been as rare in 1838, the chances would have been against their discovery by the Survey. Similarly with species of primarily northern distribution in the State; plants like *Arctostaphylos uva-ursi, Scheuchzeria palustris, Clintonia borealis, Coptis trifolia, Waldsteinia fragarioides,* and *Gaultheria hispidula* are by no means unknown in the southern part of the Lower Peninsula, but habitats suitable for them are now much restricted in area, and the fact that so many of them were found by the Survey parties in 1838 indicates either that they were more common at that time, or the botanists searched assiduously for them!

Perhaps most interesting from our point of view are the prairie plants. Undisturbed prairies have now disappeared from Michigan except for a few small areas along railroads, in cemeteries, and the like, but formerly they were dotted across the southern end of the State, increasing in size and abundance toward the southwest. The early settlers applied the term prairie not only to upland grass-covered areas of deep soil, but also to open flat and mostly inundated areas that would now be called marshes. These were at one time very abundant in southeastern Michigan, but were beginning to be drained at the time of the First Survey. The true prairies, with vegetation related to that of the Great Plains of central United States, were found primarily from Jackson County southwestward.

Often associated with the prairie plants, especially around lakes and other water-filled depressions, were species having their principal areas of distribution on the Atlantic Coastal Plain, or at least in the southeastern United States. The botanists of the Survey discovered not only some of the so-called "Coastal Plain disjuncts" (e.g. *Fuirena pumila*), and some of the maritime species that occur also around the Great Lakes (e.g. *Cakile edentula, Euphorbia polygonifolia*), but also a number of southeastern species nearing their northern limits in woodlands or in these relatively open prairie margins and wet meadows, in extreme southwestern Michigan. Notable among these are such grasses and sedges as *Andropogon virginicus, Digitaria filiformis, Stipa avenacea, Hemicarpha micrantha, Eleocharis equisetoides,* and *Fimbristylis drummondii*; such monocots as *Commelina erecta, Smilax rotundifolia,* and the rare orchid *Triphora trianthophora*; composites including *Cacalia tuberosa, Kuhnia eupatorioides,* and *Polymnia uvedalia*; and a few other species of dicots as e.g. *Buchnera americana, Eryngium yuccifolium, Swertia caroliniensis,* and *Sabatia angularis.* Some of these, including *Buchnera americana, Commelina erecta, Digitaria filiformis,* and *Polymnia uvedalia,* seem never to have been found in Michigan since the First Survey, and none of the others is common in the State at the present time.

As for the prairie species, Wright's list included not only the more common and adaptable species that are still common or even weedy in many

places in southern Michigan (e.g. *Andropogon scoparius, A. gerardii, Bouteloua curtipendula, Sorghastrum nutans, Ratibida pinnata, Silphium perfoliatum, S. terebinthinaceum,* and *Coreopsis tripteris*), but also some of the rarer species that have since disappeared (or nearly so) from the Michigan scene (e.g. *Amorpha canescens, Aster sericeus, Baptisia leucophoea, Coreopsis palmata,* and *Echinacea purpurea*).

For what reason I cannot say, a rather high percentage of the rare and unusual species reported by Wright are represented by specimens in the Michigan herbarium. There are no specimens, however, for many of the common woodland species of southern Michigan. Perhaps some past curator of the herbarium discarded duplicate sheets of the common species because the collection at that time contained better and more modern specimens of the same species. Some few of the most interesting of Wright's reports cannot be documented, but most of the doubtful ones refer to distinctive species, and I am inclined to credit the reports. Among those species for which there are no supporting specimens at the University of Michigan are *Andropogon virginicus, Diarrhena americana, Stipa avenacea, Ludwigia alternifolia, Swertia caroliniensis, Onosmodium hispidum,* and *Eupatorium sessilifolium.* Apparently no species of *Onosmodium* is known from Michigan; the others are all known, but rare, in the southern part of the State.

No discussion of the work of the First Survey would be complete without some mention of their discoveries of rare species and species new to science. That there were relatively few of the latter is an indication of how well the flora of the Midwest was known by 1840, primarily through the pioneer work of Nuttall, Michaux, Rafinesque, and a few others. Most of the new species collected at the time of the Survey were not recognized as such until somewhat later. The most interesting species are as follows:

Asplenium ruta-muraria L. Sp. Pl. 1081. 1753. Collected on Drummond Island by Houghton and Bull on August 3, 1839, on the limestone headland commanding the passage between Drummond and Cockburn Islands. This, the American representative of the common Wall-rue of Europe, is apparently unknown from Michigan except at this locality, where it was re-discovered in 1961 by Jarl K. Hiltunen; see Brittonia 14: 120. 1962. At the Drummond Island locality the plant grows with another and almost equally rare Michigan fern, *Pellaea glabella* Mett., which was also collected by Houghton.

Gymnandra bullii Eaton, in Eaton & Wright, N. Am. Bot. 259. 1840. (*Wulfenia bullii* of Gray's Manual, 8th ed.; *Besseya bullii* as treated by Pennell, Acad. Nat. Sci. Philadelphia Monog. 1: 378. 1935). The type locality was stated by Eaton as "Prairies of Mch." Pennell, although he examined most of the specimens of Scrophulariaceae in the United States at the time of his revision, was unable to locate any of the original material, and there is none in the University of Michigan herbarium. Perhaps the amount collected in the first place was small, as Wright wrote to Torrey (who apparently had asked to see a specimen) and informed him he was sending "all the remaining material." Perhaps a part of the type material, not recognized as such by Pennell or not seen by him, may yet be found among the Torrey plants at New York.

Solidago houghtonii Torr. & Gray ex A. Gray, Man. 211. 1848. The type locality was given as "North shore of L. Michigan; collected in the Michigan State Survey." An isotype at Michigan is labelled "Aug. 15th 1839 North shore of Lake Michigan." As Voss[27] has shown, the type material, undoubtedly collected by George Bull, came from

[27]Jour. Sci. Lab. Denison Univ. 44: 28. 1956.

somewhere between a point about four miles southeast of the present site of the village of Epoufette and four miles west of the present village of Naubinway, in Mackinac County.

Echinodorus parvulus Engelm. in Gray, Man. ed. 2. 438. 1856. Recorded by Engelmann, at the time of the original description, from Michigan, but not known from that State except through one of the collections made by the First Survey (from White Pigeon, St. Joseph County, August 11, 1837). Voss[28] has discussed this in detail and concludes that the specimen in the University of Michigan herbarium may be part of the type-material. A specimen at the Gray Herbarium is labelled by Gray himself, "Michigan State Coll[ection]." This is probably the basis for Engelmann's report of the species from Michigan, as according to Voss there is no specimen from this state among Engelmann's own plants at the Missouri Botanical Garden.

Lysimachia stricta var. *producta* A. Gray, Man. ed. 2. 272. 1856. Gray's specimen was from Michigan, without statement of definite locality or collector, but labelled "Mich. State coll[ection]." Voss[29] has documented this case and concludes that the specimen at the University of Michigan, labelled as from Branch County, Aug. 1 [1837], is an isotype. The plant is now regarded as an interspecific hybrid, *Lysimachia* X*producta* (A. Gray) Fern.

Cirsium pitcheri Eaton, Man. Bot. N. Am. ed. 5: 180. 1829. Pitcher's thistle, although neither a new species at the time of the First Survey nor a particularly rare one in its own specialized habitat on the dunes of the upper Great Lakes, was collected by Wright near St. Joseph, Berrien County, and included by him in his 1839 report. It is mentioned here because his was presumably the first report from so far south. Earlier records were from Mackinac Island and from Lake Superior.

Scirpus olneyi A. Gray, Boston Jour. Nat. Hist. 5: 238. 1845. This is a widely distributed but rather rare sedge, known in Michigan only from a few localities in saline marshes in the Grand River valley. Douglass Houghton, traveling by canoe in 1837, ascended the Maple River to a "Salt Works" in southern Gratiot County. On July 23 he collected this species, or what may be a hybrid between it and *S. americanus,* in the saline marshes near the "works." Exactly 123 years later, July 23, 1960, Dr. Voss found the very marsh that had been the source of the specimen and, a little further down the river in Clinton County, by following the directions in Houghton's original field diary, he found another locality where *Scirpus olneyi* was still growing in a similar marsh.

Plantago cordata Lam. Tabl. Encyc. Méth. 1: 338. 1791. This interesting and relatively distinctive species of plantain was recently the subject of an article in this journal.[30] It was formerly rather widespread in moist calcareous soils in northeastern United States, but is apparently sensitive to pollution and other changes in the environment, and has become very rare. It was collected near Port Huron by Wright in 1838, and at a few other localities in southeastern Michigan by later collectors, but Mr. Tessene has been unable to find any localities where the plant is now growing in the State.

EPILOGUE

The First Geological Survey of Michigan was conceived and nurtured by a group of young men. Houghton was not yet 28 years of age when he became State Geologist; Sager was a year younger, and Wright a year younger still. The Survey in many ways was ahead of its time; perhaps it asked too much of a State that desperately needed practical results and ready cash, and could not afford to wait for the deliberate gathering of data that scientific

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[28]Mich. Bot. 6: 16-17. 1967.

[29]Mich. Bot. 6: 20-21. 1967.

[30]Melvern F. Tessene. Systematic and ecological studies on *Plantago cordata.* Mich. Bot. 8: 72-104. 1969.

methods dictated. All the young scientists that took part in the Survey must have been disappointed to see their work come to naught. The geological aspects of the Survey were, it is true, supported by the State until some results could be seen. The botanists, on the other hand, have had to wait more than a century and a quarter for any sort of recognition, and it is only to be regretted that the traces of their work have been so meagerly preserved.

GAZETTEER

The following list does not include names of well-known application that have been continuously in use for the same place since the period of the First Survey, except for the names of certain counties that have been (or may be) confused with specific localities in the same or other counties.

Ann Arbor, Washtenaw County. Collections were made June 23, 1838, in a "sphagnous swamp" around a small lake 2 miles west of Ann Arbor. This was probably Second Sister Lake, which until recently supported a sphagnous mat with many characteristic associated species.

Austin Lake, Kalamazoo Co. See Sand Lake.

Berrien, Berrien County. Collections were made on "banks of the St. Joseph River, Berrien," August 17, 1838. As late as 1850 the name Berrien was applied to present Berrien Springs.

Bete Gris Bay, Keweenaw County. Houghton worked in the vicinity of what he called Bay de Gres, June 27-July 1, 1840. Specimens labelled "Lac Bay de Res of Lake Superior," June 30, 1840, are presumably from the shore of Lake Superior or from Lac La Belle, almost south of Copper Harbor on Keweenaw Bay.

Black River, St. Clair County. See Clyde.

Branch [County]. On Hubbard's labels of 1837, "Branch" is written sometimes as if it were the name of a specific locality, but probably "Branch County" is meant; cf. Lenawee, Hillsdale, St. Joseph. There was also a settlement called Branch (named, like the county, for John Branch, Secretary of the Navy under President Jackson), situated on the Coldwater River, a few miles south of Mason (or Masonville), which was also on the river. The town of Coldwater was about a mile northeast of Branch, at the edge of the "Coldwater Prairie," and east of the river. The modern city of Coldwater has spread away from the river onto the prairie, and Mason and Branch have long since disappeared.

Clyde, St. Clair County. At one time a settlement called Clyde or Clyde Mills, now a township traversed by the Black River, some 8-10 miles northwest of Port Huron.

Edwards Prairie, [Cass County]. Near Edwardsburgh, where collections were made August 20-28, 1838.

Goose Island, Mackinac County. In northern Lake Huron, T 41 N, R 1 W, about 6 miles south of Hessel.

Grand Prairie, Kalamazoo County. Formerly an extensive prairie area west and northwest of Kalamazoo.

Gull Prairie, Kalamazoo County. Formerly an extensive prairie area, near present Richland, west of Gull Lake.

Hillsdale [County]. On Hubbard's labels of 1837, and on some labels copied in 1870 or later, "Hillsdale" is written as if it were the name of a specific locality, but "Hillsdale County" is meant. The present town of Hillsdale was not laid out until about 1839. The older town, Jonesville, was on the "Chicago road" west of Detroit.

Hog Creek, [St. Joseph County]. Presumably near Centerville, where Hog Creek joins the Prairie River. Collections were made near Centerville, September 8-12, 1838.

Lac Bay de Res, Lake Superior. See Bete Gris Bay.

Lenawee [County]. On Hubbard's labels of 1837, "Lenawee" is written as if it were the name of a specific locality, but "Lenawee County" is meant.

Louse Island, "Michigan." Houghton's party visited here August 26, 1839. Its modern name is Rock Island; it is the northernmost island in Wisconsin on the east side of Green Bay.

Mackinac [Island], Mackinac County. At the time of the First Survey, all references to "Mackinac" refer to the settlement on the island, or to the island itself, which is about 3 miles east of St. Ignace, Mackinac County. The settlement at the present site of Mackinaw City, on the mainland south of the Straits, had been abandoned for more than 50 years.

Mason [or Masonville], Branch County. See Branch.

Menococien River, [Mackinac County]. This is the stream now called Millecoquins River; it enters Lake Michigan about 1 mile west of Naubinway.

Northfield, Washtenaw County. See Whitmore Lake.

Oakland [County]. On Hubbard's labels of 1837, "Oakland" is written as if it were the name of a specific locality, but probably "Oakland County" is meant.

Paw Paw River, mouth of, [Berrien County]. The Paw Paw River empties into the St. Joseph River at St. Joseph-Benton Harbor.

Pigeon [or Pigeon Prairie]. Evidently both these names refer to places near White Pigeon, St. Joseph County, where the botanists worked August 4-24, 1837.

Pleasant Lake, [Washtenaw County]. Collections were made here June 28, 1838, while the Survey party was working in Washtenaw County. This is presumably the Pleasant Lake in Freedom Township, ca. 12 miles southwest of Ann Arbor.

St. Joseph [County]. On Hubbard's labels of 1837, "St. Joseph" is written as if it were the name of a specific locality, but probably "St. Joseph County" is meant. The collectors passed through the county, from Sturgis to White Pigeon, August 2-24, 1837. Not to be confused with St. Joseph, Berrien County, which was the site of botanical collections August 10-20, 1838.

Sand Lake, Kalamazoo County. Not definitely located. Austin Lake, and the smaller lakes surrounding it, are indicated collectively as "Sandy Lakes" on maps of the period 1835-1840. Wright, in a note to Torrey, said Sand Lake was a small lake 8 or 10 miles from Kalamazoo, which is about the right distance for Austin Lake.

Sherman, St. Joseph County. Old maps show Sherman approximately at the present site of Sturgis, and Sturgis (or usually Sturges) Prairie a little west of Sherman.

Squaw Island, Detroit River. This locality appears on a specimen labelled by Hubbard, with date of June 16, [1837]. I cannot find any island so called; it may have been an early name for one of the islands in the river on the Michigan side, or one of the Canadian islands.

Sturges Prairie, St. Joseph County. See Sherman.

Thunder Bay, [Alpena County]. Specimens of *Pinguicula vulgaris* and *Iris lacustris* are labelled "Thunder Bay." Houghton was in this vicinity, June 13-17, 1838, and visited Thunder Bay Island, June 15-17. The island, which is about 4 miles offshore and 12 or more miles east of Alpena, is the southernmost known Michigan locality for *Pinguicula vulgaris.*

White Rock, Huron County. A specimen is labelled "White Rock, Oct. 8, 1837." Houghton and Hubbard passed here on this date, but did not land. Houghton's map shows the rock 1900 feet off shore, in Sect. 29, R 16 E, T 15 N.

Whitmore Lake. Visited by a botanical party, June 21, 1838. The lake is about 10 miles north of Ann Arbor; its southern half is in Northfield Township, Washtenaw County, and its northern half in Livingston County.

Wolf Lake, Lenawee County. There is a lake of this name, near the highway, about 12 miles west of Clinton. A single collection is labelled as from Wolf Lake, September 14, 1838.

GRIMMIA AGASSIZII, A MOSS NEW TO MICHIGAN

F. J. Hermann
Forest Service Herbarium,
Washington, D.C.

Five species of *Grimmia* (one of them, *G. apocarpa,* with six recognized varieties) are ascribed to the state in Darlington's The Mosses of Michigan (1964) and a sixth (*G. plagiopoda*) has recently been reported (Mich. Bot. 9: 140) by H. A. Crum. Still another species, *G. agassizii* (Sull. & Lesq.) Lesq. & James was encountered in Baraga County by the writer on June 27, 1969 (*F. J. Hermann 22646,* US, DUKE, NY, MICH). There it occurred as an extensive colony on a granite ledge at water's edge along the Sturgeon River, 11 miles SSE. of L'Anse. An earlier collection from Keweenaw County had not at first been recognized (*F. J. Hermann 16370,* MICH, CAN): on periodically submerged rock in Gratiot River, 2 miles SW. of The Cliff, August 31, 1960.

The distribution of this species was given by G. N. Jones, in Grout's Moss Flora of North America (2: 11-12. 1933) as "on dry rocks, Quebec and Ontario; British Columbia; Utah, Europe." But the plant occurs over a much wider range than was then supposed, the writer having collected it in Maine, New York, Alaska, Oregon, Idaho, Montana, Wyoming, and Colorado in addition to Michigan. Citations for five of these nine localities were given in The Bryologist 67: 173. 1964. In every instance, except for the granite ledge along the Sturgeon River, the moss was growing on boulders, usually granite or gneiss, in or on the banks of streams or rivers, often blackening them in colonies of considerable size.

A member of the subgenus *Schistidium,* the species is nearest allied to the strictly maritime *G. maritima* Turn., but it bears a superficial resemblance to *G. alpicola* var. *rivularis.* From this it differs markedly in its funnel-form (rather than urceolate with round base) capsule with widely flaring mouth. Vegetatively it differs from *G. alpicola* and its var. *rivularis* in having at least the lower leaves narrowly lanceolate, not carinate, nor repand or dentate at the apex and the margins not at all consistently recurved, whereas in *G. alpicola* the margins remain conspicuously recurved and the leaves are so carinate that a good proportion of them remain folded when mounted on a slide. A form of *G. agassizii* with dimorphic leaves, however, is of frequent occurrence and may be confusing. In this the upper leaves, especially those of the sterile stems, are ovate, definitely keeled, at least toward the apex, and often with the margins in part revolute, so that they are very suggestive of *G. alpicola;* but the lower leaves are always distinctive. A further distinction between the two species lies in the color of the plant, the lower leaves in *G. agassizii* being black (never so in *G. alpicola*) and even the upper leaves much darker green than those of *G. alpicola.* The walls of the upper leaf cells in *G. agassizii* are greatly thickened. The leaf margins are thickened and bistratose, contrary to the statement by Jones.

MICHIGAN PLANTS IN PRINT

New Literature Relating to Michigan Botany

A. MAPS, SOILS, GEOGRAPHY, GEOLOGY

Dorr, John A., Jr., & Donald F. Eschman. 1970. Geology of Michigan. Univ. Mich. Press, Ann Arbor. 476 pp. $15.00 [A magnificent volume which should be invaluable for anyone interested in the natural history of the state. See review on p. 206 of the May issue.]

Haines, Donald A., & Rodney W. Sando. 1969. Climatic Conditions Preceding Historically Great Fires in the North Central Region. North Central For. Exp. Sta., U.S. For. Serv. Res. Pap. NC-34. 19 pp. [Includes data on the 1871 and the 1881 (Thumb) fires in Michigan.]

B. BOOKS, BULLETINS, SEPARATE PUBLICATIONS

Chase, Clarence D., Ray E. Pfeifer, & John S. Spencer, Jr. 1970. The Growing Timber Resource of Michigan 1966. North Central For. Exp. Sta., U.S. For. Serv. Resource Bull. NC-9. 62 pp. [Presents statistics from the third forest survey of Michigan, showing sizable gains in growing-stock and sawtimber volumes since 1955. A rough map of major forest types in Michigan is on the inside rear cover.]

Smith, Bruce D., ed. 1970. Summer Science Journal. Vol. 2, No. 1 & No. 2. Summer Science, Inc., Ann Arbor. 105 pp. & 87 pp. $1.00 ea. [No. 1 includes student reports on historical archaeology and independent research during 1969. The latter includes a study on the diatoms of Summer Island and a hardwood-softwood survey of the island. No. 2 includes reports on aquatic biology, meteorology, plant ecology (a fern report here), shoreline geology, and wildlife ecology of Summer Island. As mentioned in noting Vol. 1 in our May listings, the reports reveal the orthographic and other inexperience of their youthful authors, but valuable data on this island off the Garden Peninsula are recorded.]

C. JOURNAL ARTICLES

Bigelow, Howard E. 1970. Omphalina in North America. Mycologia 62: 1-32. [Four of the species are cited for Michigan, without further locality.]

Byer, Michael D. 1970. Interspecific plant association as influenced by three variables. Ecology 51: 103-112. [Changes in interspecific association related to variation in quadrat size, position on a gradient, and abundance measure, studied in southern Crawford Co.]

Cooperrider, T. S., & G. A. McCready. 1970. Chromosome numbers in Chelone (Scrophulariaceae). Brittonia 22: 175-183. [2n = 28 or n = 14 reported for *C. glabra* var. *linifolia* from Berrien and Washtenaw counties.]

Davis, H. A., Albert M. Fuller, & Tyreeca Davis. 1969. Contributions toward the revision of the Eubati of eastern North America. IV. Castanea 34: 157-179. [This revision of the blackberries, more correctly called subgenus *Rubus,* continues with the sections Verotriviales (no species in our region), Canadenses, and Alleghenienses. In the synonymy of *R. canadensis* are included *R. besseyi* (type from Ontonagon Co.) and *R. laetabilis* (type from Kalamazoo Co.); the types of these and of *R. darlingtonii* (Ontonagon Co.), which cannot be placed, are discussed. In the synonymy of *R. allegheniensis* are included var. *plausus* (type from Lapeer Co.) and *R. rappii* (type from Kalamazoo Co.), and the species is also cited from Alger, Clare, and Ontonagon counties. *R. attractus* (type from Allegen Co.) is not placed. *R. rosa* is cited from Gogebic Co.]

Davis, H. A., Albert M. Fuller, Tyreeca Davis. 1969. Contribution toward the revision of the Eubati of eastern North America. V. Arguti. Castanea 34: 235-266. [This portion of a continuing monograph reduces Bailey's 120 species of native glandless highbush blackberries to 50. Kalamazoo Co. types of *R. localis, R. associus,* and *R. licens* are reduced to *R. uvidus,* for which other collections are cited from Allegan, Kalamazoo, Muskegon, and Van Buren counties; *R. cauliflorus* and *R. limulus,* both also from Kalamazoo Co., are reduced to *R. recurvans,* which is also cited from Menominee Co.; *R. hanesii* is an "odd plant" not definitely placed; *R. frondosus* is cited from Kalamazoo Co.]

Dissing, Henry. 1966. A revision of collections of the genus Helvella L. ex St-Amans emend. Nannf. in the Boudier Herbarium. Rev. Mycol. 31: 189-224 [Cites *H. stevensii* from Detroit.]

Dogma, Irineo J., Jr. 1969. Additions to the phycomycete flors of the Douglas Lake region. VIII. Chytriomyces annulatus sp. nov. and notes on other zoosporic fungi. Nova Hedw. 18: 349-365. [Observations at various places in Michigan, chiefly the Douglas Lake region.]

Dogma, Irineo J., Jr. 1969. Observations on some cellulosic chytridiaceous fungi. Archiv. Mikrobiol. 66: 203-219. [Notes on several species, mostly at various Michigan localities.]

Giannasi, David E., & C. Marvin Rogers. 1970. Taxonomic significance of floral pigments in Linum (Linaceae). Brittonia 22: 163-174. [The material studied of *L. medium* var. *texanum* and *L. sulcatum* came from Oakland and Newaygo counties, respectively.]

Kral, R., & P. E. Bostick. 1969. The genus Rhexia (Melastomataceae). Sida 3: 387-440. [Stress in this treatment is on cytological-anatomical data obtained since the 1956 monograph by James. Includes key to species and distribution maps; map for *R. virginica* shows only Van Buren and Kalamazoo counties in Michigan, although the species ranges north to Oceana Co.]

McKnight, Kent H. 1969. A note on Discina. Mycologia 61: 614-630. [Three species cited from Michigan.]

Montgomery, James D., & David E. Fairbrothers. 1970. A biosystematic study of the Eupatorium rotundifolium complex (Compositae). Brittonia 22: 134-150. [*E. sessilifolium* mapped in southeastern Michigan.]

Stuckey, Ronald L. 1970. Distributional history of Epilobium hirsutum (Great Hairy Willow-herb) in North America. Rhodora 72: 164-181. [Data, with map, include Michigan localities with stress on sequence of collections.]

Thieret, John W. 1969. Notes on Epifagus. Castanea 34: 297-402. [Distribution map includes many Michigan locations for beechdrops.]

Wetzel, Robert G. 1969. Factors influencing photosynthesis and excretion of dissolved organic matter by aquatic macrophytes in hard-water lakes. Verh. Internatl. Ver. Limnol. 17: 72-85. [Study based on growth of *Naias flexilis* from Lawrence and Gull lakes, Barry and Kalamazoo cos., in axenic culture.]

News of Botanists

STANLEY A. CAIN has been appointed the first director of the University of Michigan's new Institute for Environmental Quality. Professor of conservation and of botany at the University, he was recently designated "Eminent Ecologist," the highest honor bestowed by the Ecological Society of America, and he has also been honored by election to the National Academy of Sciences. . . . DOUG FULTON, outdoor editor for the Ann Arbor News, received the Conservation Communications Award of the year at the Michigan United Conservation Clubs annual convention in Traverse City last summer. . . . WILLIAM F. HOPKINS, long active in the Botanical Club, has been elected president of the Michigan Parks Association.

MICHIGAN FLORA PROGRESS

Part I of a flora of the vascular plants of Michigan is nearing completion. It will include keys to gymnosperms and monocots, together with distribution maps showing the counties from which each is known. The maps will be based only on specimens actually examined, not on literature or manuscript reports, as reliable as these may be. Therefore, all existing collections should be examined. Many Michigan herbaria, and a few outside the state, have been collaborating for several years, but some significant Michigan collections have doubtless been overlooked. Persons in charge of private or institutional herbaria containing Michigan specimens which might be made available and with which arrangements have not yet been made for checking, are encouraged to notify Edward G. Voss, Herbarium, North University Bldg., University of Michigan, Ann Arbor, Michigan 48104.

Publications of Interest

LICHENS OF OHIO Part 2. Fruticose and Cladoniform Lichens. By Conan J. Taylor. Biol. Notes 4, Ohio Biological Survey, Columbus, 1968. pp. 153-227 + 22 pp., plastic bound. $3.00 from Publications Office, Ohio State University, 2500 Kenny Rd., Columbus, Ohio 43210. This work continues with the same kind of excellent photographs, distribution maps for Ohio, keys, and descriptions as in Part 1, noted here earlier (Vol. 7, p. 189. 1968). Present plans call for Part 3, on the crustose lichens, to complete the group with a year or two.

THE OXFORD BOOK OF FOOD PLANTS. By S. G. Harrison, G. B. Masefield, & Michael Wallis. Oxford University Press, London, 1969. 106 pp. 55s [=$6.60]. Handsomely and thoroughly illustrated in color by B. E. Nicholson, this volume is a popular guide to food plants of all kinds (including herbs and beverages) from all parts of the world. There are general notes on culture, origin, distribution, parts used, and such matters. Scientific names are given but without authorities, the families to which the plants belong are seldom mentioned, and there are no references to other literature. The botany student, therefore, may be somewhat frustrated, but the book is sufficiently complete, attractive, and apparently authoritative to appeal to the gourmet or housewife. An omission which may be missed is the recently promoted "kiwi fruit" (*Ziziphus jujuba* Mill., in the Rhamnaceae).

NOTES: A reprint edition of *Natural Areas in Indiana and Their Preservation,* reviewed over a year ago (Vol. 8, p. 150, May 1969), is now available from the American Midland Naturalist, Department of Biology, University of Notre Dame, Notre Dame, Indiana 46556. The price is $5.50 and orders placed by individuals must be prepaid. . . . A list of revisions and additions to *Check-List of the Vascular Plants of the Bruce Peninsula* appears on three pages (unnumbered) in the Federation of Ontario Naturalists Newsletter, Vol. 11, No. 3 (May-June-July, 1970). Included are some of the records presented by George Thomson in the extended review in our January issue (Vol. 9, pp. 9-16). The discovery of *Listera ovata* in the Bruce is written up in the April-June number of Rhodora (Vol. 72, pp. 274-275).

MICHIGAN BASE MAP

Because a number of articles in *The Michigan Botanist* refer to Michigan localities by county, we respond here to suggestions by readers, and print a base map of the State as a preface to the Index.

INDEX TO VOLUMES 7-9

With the exceptions here noted, this index is intended to be complete for the three volumes, including all scientific names of genera and species, titles (by important words), authors, and subjects. NOT indexed, in general, are the following: news items, program notes, announcements, etc.; items in literature lists, bibliographies, and summaries; common names or names of taxa higher than genus or lower than species, except when there is a major discussion or use of them. Reviews are ordinarily listed only (by title) under "Reviews"—not under the author or title of the works reviewed, nor under the reviewer's name; "Publications of Interest" are not indexed although that heading is. Pictures are indexed under their explanations (whether on the same page, a facing page, or in the case of cover pictures, the rear cover). If an article has three or more joint authors, the others are cross-referenced to the senior author without repetition of title; if there are only two authors, both are fully indexed with title. Names of persons not followed by a title or cross-reference refer to information about the person. Most other references to persons are not indexed.

Some inconsistencies are inevitable as to whether or not species mentioned in passing or in habitat descriptions are indexed. Casual mention of a species (or a genus) is usually not indexed, especially if the point is not to give a record or to note taxonomic comparisons. Species (or genera) in pollen diagrams are not indexed unless there is further discussion in associated text. Also not in this index, as an economy measure, are (1) the species cited in tables and descriptions of Pennfield Bog (8: 11-27; 51-60) since all are included in the annotated list (8: 131-136), which is indexed; (2) the species in the description of Sanford Natural Area (9: 130-136) as all are indexed from the annotated list (9: 147-164); (3) the list of associates of *Plantago cordata* (8: 91). When an article is devoted to a single genus and there are many species names (including synonyms), these names are not separately indexed, as the title of the article (at least when inverted and indexed under the generic name) should indicate its contents. Similarly, if in an article devoted to a family there are one or more genera with several species, the index entry will only read "[genus] spp." to avoid listing a large number of names in an obvious context.

The attention of phytogeographers is called to the special entry, "Distribution Maps," where all species are listed for which partial or complete maps have been published.

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INDEX NOTICE

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In this issue is a single cumulative index to Volumes 7, 8, and 9 of THE MICHIGAN BOTANIST—our third triennial index. These three volumes may thus be bound together as a single unit with a single index. Note that all covers are included in the pagination and should be bound in. There are no special title pages.

Due to the increasing size of volumes, this is doubtless the last triennial index and future ones will be prepared annually or biennially.

Editorial Notes

We are deeply indebted to Miss Mary E. Cooley for the considerable labor of alphabetizing and filing the entires for the index in this issue.

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(On the cover: Cottonwoods, Populus deltoides, *on the Sleeping Bear Dunes. Photograph by Rudolf Schmid, October 5, 1969.)*

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